Can MOOCs Support Secondary Education in Computer Science?

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Abstract. Despite the importance of competencies in computer science for participation in the digital transformation of nearly all sectors, there is still a lack of learning material and technically experienced teachers in German schools. In the paper at hand, we investigate the potential of Massive Open Online Courses (MOOCs) for secondary education. Schools can profit from this learning content and format provided by well-known institutions. However, German schools provide some challenging conditions, which have to be taken into account for a meaningful integration of e-learning elements. Our statistical and qualitative results are based on the representative data of the National Educational Panel Study (NEPS), the learning data of more than 100,000 online learners from over 150 countries, and the outcomes of several workshops with teachers and school administrators.

Keywords: MOOCs · STEM · K-12 · Flipped classrooms · Learning culture · Technical teacher training

1 Introduction

Digital literacy is recognized as a very important competence for participation in society and co-creation of digital transformation. Whereas, young people are treated as digital natives and computer science plays a minor role in secondary education. Often pupils are only learning how to use common computer software without understanding the underlying mechanisms or even how to use simple commands of programming by their own. Modern learning content is still seen as a competition to traditional ideals of education[1]. A reluctance towards new tools and technologies is inherent to school systems [1].

Innovative digital concepts of teaching and learning, such as Massive Open Online Courses (MOOCs) could help handling current challenges, such as large numbers of students with diverse educational backgrounds and rapidly developing technologies. MOOCs' uniqueness is characterized by the combination of offering educational content within a social media platform, enabling the course participants to learn within a virtual community, which has turned MOOCs into an attractive learning method [2]. Moreover, MOOCs are proclaimed as a tool to foster individualization [3].

[1] This, actually, is neither a revolutionary new insight, nor is it restricted to German schools. Back in the 1990's L. Cuban examined very similar phenomena in American schools.

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However, there are still some challenging conditions, which hinder the integration of e-learning elements in compulsory education.

2 Purpose and Goal

Our aim is to adapt the MOOC format for the requirements in schools. Thereby, we hope to be able to open the common learning culture in schools. Particularly in computer science, MOOCs can support secondary education as the schools are still lacking proper resources in this area. Related research is mostly focused on MOOCs in the field of tertiary education [4]. From our sociological and technological perspectives we investigate mainly on the following research question: Under which conditions can the adaption of MOOCs support secondary learning and teaching in computer science? We assume that MOOCs will be an attractive supplemental offer for pupils if some elements of MOOCs are suited to specific requests of schools. Concerning our MOOC "Learning to Program in a Playful Way" we will present the quantitative and qualitative results of learners who were younger than 20 years old in contrast to older learners by answering the following questions: Are there any specifics in regard to gender, participation in the forum, submitted exercises, learning curves, outcomes and dropouts? Are MOOCs for pupils more or less suitable than for adults or are they promising for both target groups? We will illustrate the potentials of IT enhanced learning as well as opportunities to get over certain barriers of computer assisted learning in schools. Therefore, we will discuss practical aspects of educational application of IT by using the example of the implementation of MOOCs in school contexts.

3 Literature Review

Related research ascertained that 98% of youth and young adults[2] in Germany are online. Being online can be considered as an important element of societal participation. However, pupils, whose families come from a high socio-economic background, are more confidential in using the Internet [5]. Compulsory education could support disadvantaged pupils and prevent widening the digital divide within society. By the age of 14 teenagers are using the Internet to a great extent independently. They are joining online communities early and use them intensively [5].

Technology in general and Internet technology in particular, attracts more and more attention in the educational sector [6]. In Germany, digital education is one of the key issues at the National IT Summit 2016[3].

The Internet offers the potential and challenge to transform the landscape of learning. By now the biggest effort of incorporating the Internet into education was expended in higher education. In General, older students are expected to be more capable to choose between different modes of study and to handle the worldwide web

[2] 14 to 24 years old.

[3] The IT summit is one of the main political instruments to implement the German Digital Agenda [7] – Germany's strategy to foster and shape digital transformation [8].

than children. “The Internet is not primarily an educational tool, but it self-evidently offers unique and unparalleled scope for the exploration of new forms of collaboration in the development and sharing of knowledge” [6].

Among many teachers the acceptance of online courses is still quite low. Good teachers are measured in regard to persuasive personality, responsibility to pupils, parents, management of the school and state authorities, individual teaching concept, high scope of interaction with pupils, well-founded knowledge of group dynamics, neutrality and objectivity. On the contrary in practical experience there is reduced possibility of individual work and environmental surroundings are very important for an effective teaching and learning culture. Teachers can only offer possibilities, while choice remains to pupils themselves [5]. Online settings and computer supported collaborative learning broaden this range and are a promising option for many pupils to gain access to appealing or gaming learning content [6].

4 Approach

We are analyzing representative data of the National Educational Panel Study (NEPS) concerning the current situation of computer science in German schools. Secondly, we have access to the learning data of more than 100,000 learners who participated in MOOCs about computer science provided by the online learning platform *openHPI* [9][4]. MOOCs are enforcing a defined schedule with learning materials, such as short videos[5], additional reading material, quizzes, homework and interactive as well as practical assignments. Learners are able to clarify questions and discuss further topics with each other and the teaching team via a social media platform. The four-week MOOC “Learning to Program in a Playful Way” is designed particularly for young people and was conducted twice (2014 and 2015) with more than 20,000 enrolments in total. Close to 6,000 course participants also took our additional surveys.

Furthermore, we have been conducting a modified version of this online course for two small groups of pupils in cooperation with two school teachers in the form of a so called Small Private Online Course (SPOC). In this setting, we have been experimenting with different use cases for the adaption of online courses in schools. Finally, we conducted four workshops in 2015 and 2016, discussing the possibilities of integrating MOOCs into schools with teachers and school administrators. These workshops were embedded in conferences of MINT-EC[6] and the German Informatics Society (GI)[7].

[4] HPI is subject to the Federal Data Protection Act, as the servers with the user data are situated in Germany. For platform improvement and research reasons, only anonymous data is used [9].

[5] 4-15 min.

[6] MINT-EC maintains a nationwide excellence network for German schools with a focus on Science, Technology, Engineering and Mathematics (STEM). Its declared goal is to offer outstanding learning programs for students and teachers in STEM. More than 200 schools with more than 20,000 teachers are integrated into this network [10].

[7] The GI and its 22,000 members worldwide offer a network to create early motivation and interest for informatics – supported by products to develop skills and aided by initiatives for training frameworks [11].

5 Collaborative Learning in MOOCs

openHPI-MOOCs feature a fixed start and end date and follow a weekly interval. Course participants have access to these learning materials at any time suitable for them, and as often as needed. However, all participants who are collecting points for a Record of Achievement, have to finish graded homework and exams in a timeframe defined by the teaching team. The format, hereby, allows a certain amount of flexibility for the participants, while providing a framework that enables the learners to feel the social presence of their fellow students.

Graded homework assignments are part of the requirements to receive a Record of Achievement. Additional assignments serve as practical or interactive tasks in which course participants can directly apply their recently acquired knowledge – e. g. coding assignments, which are embedded in *openHPI* via external tools, using the LTI interface [12–14] or the *Solution Through Execution Pattern* (STEAP) [15]. Another form of assessing these exercises are peer assessments, where participants grade each other's work. It can be used wherever automated grading is not possible or where the setup of assessments would be too time consuming. Another benefit is the requirement to reflect about the work of the peers [16] – and their own. The effort invested will pay off by improving one's understanding of the course material.

Learning experience is essentially enhanced by active participation in discussion fora. Interaction within the learning community contributes to the participants' learning process. Further features are offered, e. g. public or private *collab spaces* (learning groups). They are rather unique in the context of the large MOOC platforms and enable smaller groups to collaborate more intensively on special interest topics. They can be created by all course participants [17].

6 Outcomes

In the following subchapters we describe the current situation of computer science in schools, pupils' experiences of learning in MOOCs and teachers' and school administrators' attitudes to MOOCs in schools.

6.1 Current Situation of Computer Science in Secondary Education

German schools have two computer science teachers, on average. Usually, schools are equipped with 50 computers which provide an Internet connection, are at least two years old and located in computer pools. Access to computer labs "is dependent on internal power relations between different subject departments and teachers" [6]. Many teachers have little experience in using e-learning tools and do not feel comfortable with using technical equipment in schools because of their own uncertainty and the perceived unreliability of technology[8]. Representatively surveyed teachers ranked skills

[8] Another critical argument concerns the large amount of time pupils already spend by using technical equipment [18].

about computers and Internet on the third most important position of their own further education (see Fig. 1), behind educating students with specific learning needs and integrative lessons [19, 20].

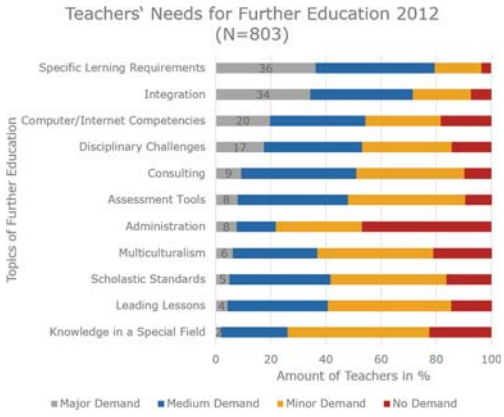

Fig. 1. Teachers' needs for further education 2012

6.2 Pupils' Experiences with MOOCs

In 2014 and 2015 more than 10,000 learners participated in the MOOC "Learning to Program in a Playful Way". In 2015 nearly 2,000 of the enrolled learners already had participated in the first iteration. 30% of all enrollments indicated their age. As it is shown in Fig. 2, in the first run of this MOOC, the amount of young students (year of birth 1995 or later) were significantly higher (23%) than in the rerun in 2015 (14%). Young students were less likely to rerun the MOOC than older learners. Among young students the amount of female learners was higher (23%) than among older students (< 20%).

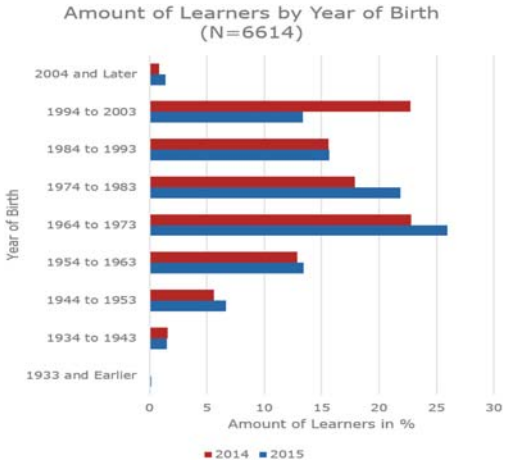

Fig. 2. Amount of learners by year of birth

With regard to participation in the forum, young learners participated more actively than older learners. Depending on the type of their posts, the amount of actively participating learners ranges from 12 to 17% among young students and from 5 to 8% among older learners. While young learners posted mostly questions, older learners more frequently posted answers. In both age groups comments on questions were posted least.

Concerning the course progress young learners reached significantly better results than older learners in all course weeks (27 to 32% better). Independent of age, the engagement declines during the course (see Fig. 3).

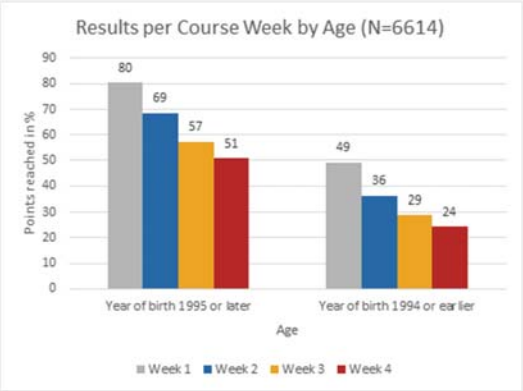

Fig. 3. Results per course week by age

More than 65% of the young learners earned a Conformation of Participation for accessing more than 50% of all learning materials, while more than 65% of the older students dropped out (p-value=0,2***). In average young learners are reaching more points than older learners. Differences in the motivation to complete the MOOC successfully may exist.

6.3 Teachers' and School Administrators' Point of View

Teachers and school administrators developed use cases for integrating (existing) MOOCs in schools in combination with necessary technical requirements provided by the MOOC-platform. They discussed the following potentials, challenges and framework conditions of MOOCs, in secondary education:

- Changing role of schools, teachers and teaching culture
- Technical equipment
- Legal issues and requirements

Schools are exposed to many changes and reformations, e. g. the transformation from teacher-centered teaching to autonomous learning. The importance of peer communication and mutual support increases. The role of teachers is changing from an instructor to a constant companion. Some teachers see their changing role as a threat to

their profession. High-level innovations, such as learning platforms are far away from traditional teaching culture in schools. Apart from this it is a very promising approach to create "synergies between school learning practices and home learning practices" [6] by organizing learning activities in school in accordance with pupils' learning in other contexts (e. g. information sharing, collaborative problem solving).

As many teachers criticize the availability and condition of technical equipment in schools innovative concepts are currently developed. The cloud technology is very promising for contemporary scholastic education in all subjects that can profit from a modern technological support. Via clouds pupils have comprehensive access to latest IT systems and e-learning programs, which are serviced professionally. This solution disengages teachers to maintain hardware. Schools only need display devices. Related computers run in a professional datacenter, which are connected to the devices in schools via Internet. From any workplace, pupils have access to individually equipped virtual machines via a remote desktop connection[9]. Altogether, the advantages of clouds concern flexibility, user friendliness, security, availability and cost efficiency. All stakeholders, particularly the teachers have to be consulted and listened to in depth[10]. Teachers have to be trained in the use of the infrastructure as well as the use of these tools. Teaching styles have to be reconsidered. E. g. the *One Laptop per Child* initiative has shown that technology in itself is not a solution [21]. Wherever the initiative can be considered successful it came along with a switch from an instructive to a constructivist teaching style. Wherever the technology was just mounted on top of existing structures, it ended in oblivion.

Some schools already use specific learning management systems (e.g. Moodle) and are not interested in using yet another e-learning-tool because of strict requirements to data privacy of their pupils. In this context the collection of pupils' data by a third party is seen as critical as the monitoring of pupils' learning behavior that can hinder exploratory learning because of anticipated negative assessment of not stringent learning activity.

6.4 Teachers' Requirements for Using MOOCs in Schools

To conduct a MOOC in a school context teachers wish to be supported technically in the following aspects:

- "Batch registration" for the platform, a MOOC and collab space
- Consideration of curricula
- Didactically profound application
- Integration of MOOC-content into existing learning managements systems
- Provisions against cheating, undesirable content and cyber mobbing
- Insights into pupils' learning progress

[9] A cloud provider should provide the infrastructure. Administration should be part of the responsibilities of either a government agency or a private company, which is commissioned by a government authority to take care of this task.

[10] Further necessary considerations are the learning materials and tools to be used with such an infrastructure.

The first challenges by using a MOOC in schools can already appear during pupils' registration processes. At *openHPI* a double opt-in registration is required[11]. If learners do not receive the confirmation email, they have to check their spam folder and can request a new confirmation email logging in with their access data previously selected[12]. If their account is already confirmed but they cannot log in, they have to make sure that JavaScript is enabled and cookies from our site are accepted. If it still does not work, they have to use the "Reset Password" function in the login form [9]. Plenty of things that can go wrong and might result in the loss of learning/teaching time. A so called "batch registration" is able to facilitate the registration process of several pupils without entering a proper email address, but registering all of them by the teachers' email account. In this context it is crucial to enable pupils to change their passwords by themselves[13]. In addition, it is important that pupils can later transfer their learning results into a regular account of their own for lifelong learning. After the registration at the platform pupils have to enroll into a certain MOOC, additionally they can join a collab space. This process should also be simplified.

Another big challenge for integrating MOOCs in schools is provided by the curricular requirements, which differ among countries, federal states and even schools. Today, computer science is not yet a compulsory subject and not bound to curricula in many federal states and inter-school discussions could be very inspiring [6]. Nevertheless, exercises have to cover the whole range of requirements. At the current state most MOOCs make use of multiple choice and multiple answer quizzes, which can be easily evaluated. More complex exercises are conducted in peer assessment. The majority of the teachers in the workshops agreed that peer assessment is an adequate technique for pupils starting from eighth grade. In addition to this many innovative exercises are provided in MOOCs, such as practical programming exercises with automatically assessed solutions and immediate feedback, which could be integrated in schools' existing learning management systems even without running a whole MOOC in class. Some other exercises in MOOCs could be replaced by those designed by teachers themselves. The majority of the teachers mentions the lack of didactical concepts as the major hindrance for the integration of online learning content into schools. Further interdisciplinary exchange between MOOC providers and teachers is required. A MOOC about "How to Use Educational Technology in a Meaningful Way" could help teachers.

For a promising integration of MOOCs in schools the content, period, time exposure, length and difficulty level in online sessions should be compatible to the lessons in schools. The amount and length of lessons, the performance level and range of performance differ widely between classes, so that a MOOC with synchronized learning periods and consistent learning content is not easy to incorporate into lessons.

[11] To finish the registration process, the learners have to confirm their ownership of the provided email address by clicking on a link in an email that is sent to them by the system right after their registration.

[12] As long as their account is not confirmed, a message appears with a link to request a new confirmation email.

[13] While the teacher should not necessarily have the possibility to access the students' passwords, he/she needs the possibility to reset them for organizational reasons.

Instead of squeezing pupils into such a predefined structure teachers should be able to adjust deadlines for their students to a certain degree. An additional challenge is to design exercises for a massive audience in a way, which makes it difficult to just copy and paste the solutions of other students.

Online proctoring is one approach to guarantee that the registered pupil does the assignments by him- or herself. The learner's photo is taken during the registration process and during the assignments via webcam. These are compared by the means of face recognition algorithms by one of our partners. One of the photos taken during the registration process is then be placed on the pupils' certificate [9]. The drawback here is that this is a paid feature, which limits its usefulness in schools drastically. An easy alternative, however, is to have the students write their tests in class and have the proctoring being handled by the teachers.

Equal access to the exam questions is a prerequisite to use the results that have been achieved in the MOOC in the pupils' next school report. To enable this, the teachers requested exercises, which can be enabled exact to the minute when a lesson starts. Anyway, many schools have specific requirements concerning the recognition of achievements as relevant for the mark in a school subject. For that reason, some teachers would prefer their pupils to write tests about the course content, which have been designed by the teacher him- or herself.

A very important subject concerns the protection of young learners from undesirable content [6] and cyber mobbing[14]. On *openHPI* inappropriate behavior in the forum and collab spaces, such as insults, can be reported by other learners to the teaching team. Corresponding posts are deleted immediately and the authors are admonished per email to stop such comments. Participants are blocked if they repeat such negative behavior. On *openHPI* it happened only 2 or 3 times that a user had to be blocked. This, however, always happened in the MOOCs for school kids[15].

We conducted a sentiment analysis to determine the overall mood in the forum. For that purpose we integrated an open source sentiment analysis library in our discussion forum[16]. This library tokenizes the sentences of a post in the forum and assigns a numerical score to this token for its average sentiment. Finally, the sentiment of a post is determined by the overall score of the tokens. All scores smaller than -0.25 are considered negative, -0.25 to 0.25 are considered neutral and ever score greater than 0.25 is considered positive [22]. In the MOOC "Learning to Program in a Playful Way" from 2015 the posts are in average neutral (−0.25 in regard to the subsample of young learners and −0.21 among adult learners). The posts of young learners tend a little bit more into the negative direction than among older learners, but the difference is not significant.

Another feature that has been requested by many teachers, is a continuously updated overview about pupils' learning progress. It helps teachers to support and

[14] Related research indicated that, according to one third of young people in Germany who were surveyed representatively, mobbing is one of the major risks of using the Internet. 3% experienced mobbing already on their own [18].

[15] For reasons of child protection we did not promote the usage of Google Hangouts, e. g. for video calls, in those courses.

[16] https://github.com/7compass/sentimental.

assess pupils' achievements adequately. Some teachers, however stated, that there is a requirement for "gaps" in the monitoring of the students to provide them with a certain degree of liberty.

In theory, the communication in the forum could support teachers to follow and understand pupils' learning processes, difficulties and background discussions as well as "to manage and maintain the focus of attention and discourses within the classroom in ways that are not easy if individuals are privately engaged with their own trajectories of enquiry and interest" [6]. In our experiment, however, it turned out that the pupils did not use the forums at all. The main reason was that they were seeing each other every day and were able to communicate face to face directly. Another reason was that they prefer to use their standard tools of digital communication, such as *What's app* or *Facebook*. The willingness of teacher's, even if it is only suspected by the pupils, might actually be another reason why they prefer to use communication channels that teachers cannot access without the pupils' active permission[17].

6.5 Useful Scenarios for MOOCs in Secondary Education

MOOCs can already be quite useful for teachers and pupils in schools in regard to the following scenarios:

- Differentiation in regard to learning rates, educational trails and learning types
- Repetition, rework and homework
- Replacement lessons
- MOOCs developed by pupils and for pupils
- Blended learning setting

Teachers are confronted with many challenges, some of them exist already since a long time, and others more recently gained increased relevance. One of the current issues is the requirement to provide individual support, guidance and company for the different pupils. Differentiation is considered to be an efficient way to learn new things according to personal potential, pre-knowledge and individual learning behavior or strategies without being isolated. Nevertheless, in educational praxis the implementation of those ideals on the content, didactical, methodological, social and organizational level often entails challenges in regard to the lack of experience of teachers, missing learning materials etc. [23]. MOOCs could step in here, e. g. to match learning content to different learning rates. To offer diverse learning methods is fundamental for fostering education of diverse learners.

The potential of educational data mining and learning analytics in the meaning of measurement, collection, analysis and reporting of data about online learners in terms

[17] One of the authors has made a similar experience while teaching a face-to-face course at a University of Applied Sciences for several years. Even rewarding the students with bonus points for using a discussion forum in Moodle did not increase the activity in this forum. When asked why, the students replied that they preferred to discuss on Facebook as they could discuss there more freely without being under constant judgement of the teacher.

of understanding and optimizing learning and learning environments is currently a research topic of great interest[18].

MOOCs enable teachers to provide innovative, motivating, and challenging e-learning material for high achievers[19]. The possibility of anonymous learning and communication in MOOCs could encourage shy pupils to engage actively in the written discussion. MOOCs can be even suitable for pupils with specific learning demands, such as Asperger. Due to the large and increasing amount of MOOCs, teachers are even able to employ courses with different difficulty levels within one class.

MOOCs are already very helpful to repeat educational content, which was taught some month or even years ago and thus help stabilizing or improving this knowledge. They can further help to fill learning gaps in the case of missed classes and can complement regular lessons in regard to specific topics where external expertise is wanted. For many pupils MOOCs can be an attractive format for doing homework. Via social media tools pupils who e. g. get minor familial support can easily ask other pupils who can give advice immediately when a question appears or somebody stagnates in solving a specific task. Thus, MOOCs can "enhance the lines of communications between schools and home" [6]. In self-paced courses pupils can learn without any deadline. For that reason they can split their attendance in MOOCs to several replacement lessons during a school year.

A very interesting use case would be the development of a MOOC by pupils and for pupils. This learning methodology suits very well to interdisciplinary and independent learning. By creating their own MOOC pupils learn not only how to use such a platform. To a greater degree they learn how to apply MOOC-technology for their own purposes, including the generation of learning content, preparing presentations, video production and managing all steps in a team. At the HPI we have made several experiments in that direction. Currently we are working on a pilot project in which a 20-years-old student is conducting her own two-week MOOC about "How to Design My Own Web Page" [24]. The course is designed to appeal to pupils, especially girls[20]. In her MOOC the young teacher shares her knowledge about designing a homepage and wants to encourage young people to create their own web page. Prof. Dr. Johanna Wanka, Federal Minister of Education and Research, gave a video statement about this MOOC at the CeBIT Global Event for Digital Business in Hannover, Germany. She pointed out that digital media is an important gateway to the world of today and the future. Digital and media competence are central aspects of general knowledge. It is inevitable to master technology, not only to write emails [25]. Via a web page young people are able to create their own communicational offer. It is essential to make use of the opportunities of digitalization intensively and to participate via digital media. Smart

[18] Often, however, these learning analytics are still reduced to counting clicks on an e-learning resource. It requires great care not to misinterpret this data, e. g. defining active students by the amount of clicks.

[19] Additionally, e-learning is "enabling learners to take a more active role in their own learning" [6] in terms of autonomous and autodidactic learning.

[20] The young teacher is studying IT systems engineering and developed her first own web page at the age of 10 years.

girls and young women are encouraged to be confidential in regard to their technical capabilities [26].

We have previously conducted an experiment with some students at the HPI. In winter semester 2014/2015, we conducted an on-campus course with six students to design, implement, and conduct an introductory course on Java programming. Under scientific guidance of three PhD candidates, the students designed the learning materials and implemented practical programming tasks including unit tests to automatically evaluate the handed-in solutions of the course participants. The students also participated in recording the videos, always in team with one of the PhD candidates. Finally, some of the students also helped to supervise the course forums and the helpdesk. In terms of enrollment numbers and completion rate, the course was a big success[21]. However, it has to be stated, that a strict revision and quality control of the students' work is crucial for such an endeavor. During the next winter semester this course will be repeated.

A blended learning scenario is currently conducted in an experiment with a modified version of the MOOC "Learning to Program in a Playful Way". The following aspects are of prior interest for this paper: In corporation with two German teachers, two groups with ten 16-years-old pupils each take part in this MOOC. This unit of instruction is conducted during regular school lessons of 45 min and additional 45 min for homework per week. Taking part in this teaching unit is compulsory for the defined groups of pupils and they receive marks for their achievements in the MOOC. The modification concerns especially the transformation of the learning content from originally 4 to 12 weeks, because the workload was pretty high[22]. In addition some very difficult exercises were deleted and the course is not public, but only accessible for the defined pupils. Mainly, we are running two different use cases for the adaption of online courses to schools: One group watches the learning videos and does the first provided task in class while the other quizzes and homework are to be done at home. The pupils of the other group watch the videos at home and do the self-tests as well as other exercises in class ("inverted classroom")[23]. The experiment is still running, but we already can report the following findings and experiences: The integration of MOOCs into schools takes a certain time for preparation, e. g. in regard to pupils' consent, scheduling, signed consent forms by pupils' parents, the purchase of technical equipment, such as headphones and the instruction of pupils. Particularly in regard to the model of inverted classroom, pupils have to be instructed in using the platform and MOOC before the first lesson takes place so that they are able to watch the compulsory videos in time. One peculiarity, which contrasts our 4-year long experience with "regular" MOOCs is the lack of communication in the forum. We designed an intervention to increase the forum usage. Tasks were designed particularly for group work. Sharing ideas with classmates in the forum

[21] It featured about 11,000 participants, with a completion rate of about 33%. In the context of MOOCs, a completion rate of 33% is a very good result.

[22] In average the amount of work involved depends on one's prior knowledge and is estimated at 5 to 10 h per week. This involves working with the videos and the course material provided, checking one's understanding of the curriculum with self-tests, completing the homework and actively participating in the discussion fora [9].

[23] This learning mode was chosen to guarantee a comparable workload in both groups.

was encouraged and bonus points were offered for each meaningful post in the forum[24]. Interestingly, up to now the discussion forum is only used by the group, which watches the videos at home and does the exercises in class – "managed collaboration on the Internet does not necessarily lead to open dialogue, open knowledge sharing, or engaging co-construction of understanding" [6].

7 Discussion and Future Work

We are still at the beginning of applying e-learning, especially MOOCs, to secondary education. We will intensify cooperation with schools and initiate further pilot experiments in the field of e-learning, computer science and secondary education. In line with our experimental development of a MOOCs by young students we are planning to conduct a project work in schools where pupils are instructed to design their own MOOC.

(Anonymized) learning analytics are a promising research subject in which we will invest our resources expecting interesting results for improving e-learning for different groups of learners and educational settings. We develop assistive tools to support the learning process. A video-conferencing solution allows to connect learners to collaborate or discuss certain topics. First test runs within our programming courses yielded promising results. Not only allowed the face-to-face communication a more direct interaction in comparison to group discussions or written forum posts, but also were participants more likely to mention their own challenges in a private setting.

Another current issue, the necessity to create and improve suited (programming-) assignments, will be tackled by a platform currently developed to share, rate, and discuss material and task templates between instructors. Albeit the ongoing effort to develop so called Open Educational Resources, this has not yet reached widespread usage in the German school landscape. Particularly, with regard to programming exercises, the sole existence of suited tasks is not sufficient since they need to be technically integrated into the pupils working environment. In order to overcome this burden, our platform is intended to support the import and export of such tasks to program executing platforms via the standards LTI and ProFormA-XML [27].

Last but not least, we will broaden our research in regard to digital education beyond learning with MOOCs. Future visions about a cloud for lifelong learning include a centralized access to educational offers of different areas and levels. Features for orientation and transparency in the wide range of digital and on-site educational opportunities are planned as well as the integration of MOOCs as an important learning mode to open and socialize online courses[25].

[24] Comparable to grades or points for oral contribution in a traditional classroom setting.

[25] In Germany, such promising visions are still struggling with its fragmented and federalist organization of education.

8 Conclusions and Recommendations

To sum up, in secondary education computer science provides a certain need for the implementation of innovative e-learning concepts. MOOCs already provide attractive exercises for pupils with immediate feedback, e. g. practical programming, project based learning and peer assessment. It is attractive to use them in schools, too. The results of our analysis show that MOOCs are able to support secondary education by providing valuable content and learning styles. Many students took part in our MOOCs highly motivated and with a very good result. Recognizably, social interaction and collaboration are essential for successful participation in e-learning tasks. By using MOOCs in a well-designed teaching framework online courses are able to contribute to current challenges, such as differentiation.

By now, the first steps into the direction of a multidisciplinary cooperation between computer science and education are done. We identified a lot of starting points to implement MOOCs into the teaching and learning portfolio of schools. Nevertheless, many teachers are still skeptical to the integration of digital media and external learning content into their own lessons. Motivating reports and lessons learned of innovative projects are needed to serve as light-houses for e-learning in schools. We recommend further education for teachers and parents concerning the usage of new media in schools. For facilitating the integration of MOOCs in secondary education some framework conditions have to be taken into account, e. g. the changing role of schools and teachers, technical support, existing learning management systems and legal framework conditions in regard to students' data privacy. Moreover, the surveyed teachers require enrolment procedures for students without a proper email but via the teacher, detailed preview of exercises and insights about students' learning progress.

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