Johannes Konert, Christoph Bohr, Christoph Rensing, Henrik Bellhäuser: PeerLA - Assistant for individual learning goals and self-regulation competency improvement in online learning scenarios (accepted for publication). In: J. Michael Spector, Chin-Chung Tsai, Demetrios G Sampson, Kinshuk, Ronghuai Huang: Proc. of the 16th IEEE International Conference on Advancing Learning Technologies (ICALT), p. 52-56, IEEE CPS, July 2016. ISBN 978-1-4673-9041-5.

PeerLA - Assistant for individual learning goals and self-regulation competency improvement in online learning scenarios

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***Abstract*— While online learning is already a part of university education and didactics, not all students have the necessary self-regulation competency to really learn on their own efficiently and effectively. In classroom a teacher can take over a moderating part, set intermediate goals and give feedback to one's progress, but participants of online learning courses (e.g. in blended scenarios or Massive Open Online Courses (MOOCs)) face a higher demand of self-regulation competency. This paper presents a course and content independent assistant, PeerLA, which assists in improving self-regulation competency. PeerLA allows setting of long-term goals, breakdown into intermediate goals and keeps track of knowledge increase or time needed. A graphical feedback allows comparison of existing and aimed level of knowledge or time investments. PeerLA adds peer comparison to the visualization charts for social frame of reference. This comparison is course-wide or only with similar learners (close in goals and knowledge levels). PeerLA is implemented as a Learning Management System (LMS) plugin to support learning progress in mixed formal and informal learning scenarios. PeerLA was evaluated with 83 students in an online mathematics preparation course over four weeks. Results indicate the benefits of such a self-regulation assistance, especially for university freshmen.**

Peer learning analytics, self-regulation competency, visualization, SCRUM, guidance, scaffolding, blended learning

I. Introduction and Motivation

In contrast to educational data mining, learning analytics (LA) aims to aggregate data in the field of technology enhanced learning (TEL), visualize it to support reflection and insight, but leave the decision and action to the stakeholders (concept of human-in-the-loop) [1]. The primary focus of research and LA software is on support for teachers to give them intermediate and immediate information about various parameters of learners' activity. Less than half of the research aims at supporting the learners themselves with such continuous analytics overview [2]. Such LA solutions for learners provide primarily data about one's own learning activities and progress, but do not allow the comparison to other peers that are similar in knowledge level and learning goals (as these aspects are hard to track). As LMS, like Moodle [1] or Edmondo [2], as well do not support a social awareness of other learners' activities, online learning consequently lacks social interaction support. The potential of peer learning is widely known, especially in constructivist learning theory it is an important part of motivation and social norming [3]. A peer learning group provides orientation about how to structure one's learning, how to set intermediate goals, what to prioritize and which scheduling of times for learning peers do. While academia is increasing use of blended learning and online learning scenarios, especially for first-term students, the learning analytics components of the used LMS need to increase their support for visualizations to learners and support for peer comparison as well. We call this the *lack of Peer Learning Analytics (L1)*.

Educational systems like universities originate from times when learners were not always-on and had an overwhelming amount of information sources at their fingertips. This availability demands a strongly developed self-regulation competency. Not all students have the needed competency level to set own goals and structure their learning activities, especially when migrating from school to university [4]. Consequently, the value of learning in classes is not anymore the offered access to information and knowledge, but the offered pre-structuring and guidance through the overwhelming amount of information (to be transformed in knowledge by learning activities). MOOCs offer primarily this value of pre-structuring and guidance (scaffolding). Still, this approach neglects the increasing diversity of learners' prior knowledge due to informal (online) learning or different prior study courses. Consequently, in an LMS a combination of predefined (formal) and individual (informal) learning paths needs to be supported that learners can set their own priorities and goals within the pre-structured courses. We call

[1] http://www.moodle.org

[2] http://www.edmodo.com

this the *lack of scaffolding for formal and informal learning together within a course (L2).*

Finally, due to the individualization of the learning paths, as well as the different prior knowledge, uncertainty increases about the time investment needed for a learner to succeed in a course. In a heterogeneous learner group an average value from prior terms is insufficient as a reference. Still, learners need orientation for their scheduling. One correct calculable value does not exist as circumstances change in each term, e.g. participants and parts of course content. Prior research ambitions to track all invested times and activities to predict needed effort to reach set goals were of limited success due to the challenge to properly track learning activities outside of the online system, e.g. learning group meetings or book reading. In this context we see for existing online learning solutions the *lack of an individualized time investment estimation (L3).*

The goal of the proposed process model and implementation PeerLA is to support individual learners in setting learning goals, tracking their progress, planning learning intervals and assist them with visualizations and comparisons to not only course peers, but peers with similar goals and levels of knowledge. To the best of our knowledge no model and implementation exists that focuses on combined support for formal and informal learning in university courses with online learning parts. Furthermore, PeerLA proposes a new approach towards self-regulated learning support by combining accepted models from psychology, computer science and pedagogy. Section II will outline the related work and approach, followed by the detailed description of the implemented process model PeerLA in Section III. After a brief summary of the implementation and evaluation in Section IV the most relevant results are shown and discussed in Section V before the Conclusion and Outlook is given in Section VI.

II. Related Work and Approach

Even though a lot of computer science research activities are reported that focus on support for learners to set, track and reach their goals in informal learning scenarios, the majority of courses contain both, formal and informal parts [5]. For such mixed scenarios with different levels of prior knowledge, different learning goals and time investment, but the same formal frame conditions, learners need a proper scheduling support to keep track of their individual goals, course goals and time restrictions. When mixed scenarios integrate online learning to allow students more individualized learning activities, the problem of learning (time) management and structuring learning into goals increases further [6], [7].

A. Using the self-regulation model

From educational psychology, concepts for improving self-regulation competency are well investigated. While several different definitions and models exist [8], we understand self-regulated learning as a learner's process of iteratively planning, acting and reflecting on learning activities towards the learner's individual goals. In this sense, the socio-cognitive model from Zimmermann and Campillo has been widely accepted [9]. It is independent from learner's personality traits. This allows its usage in online scenarios where learner profiles are not covering personality aspects or learning style preferences. Additionally, the process character of the model allows the integration with process models from agile project management (see next section). In the model a learner passes the three phases of forethought, performance and self-reflection in a cycle (see Fig. 1 for each phase's major psychological concepts and effects).

For the scenario of university courses with online learning

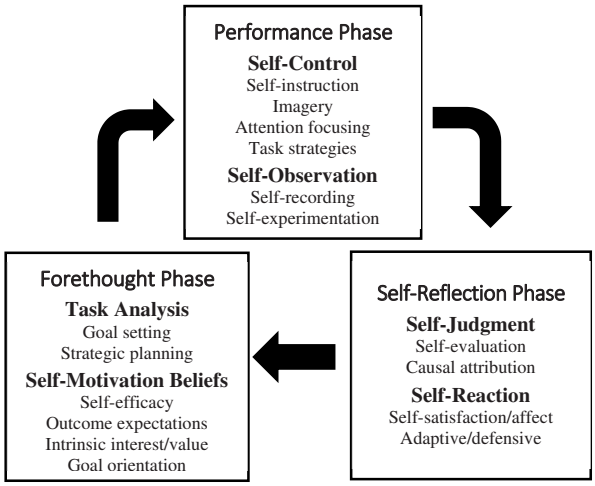

Figure 1. Model of Self-Regulation [9]

we pay specific attention to support *goal setting* and defining *outcome expectations* (Forethought), *attention focusing*, *self-observation* tracking (Performance), *self-evaluation* and *adaption* (Self-Reflection) due to sophisticated research results about the positive effect of properly set goals for learning and performance. Properly means goals that are specific, measurable, accepted, realistic and terminated (SMART) [10]. Specific goals are proven to increase self-motivation [11] and if a goal is challenging (but realistic) it is even accepted in case in may not be fully reached [10]. Mandatory termination and setting of measures allows a quantified decision about the level of success. PeerLA aims therefore for a two-level approach on goal-setting as suggested by result of Bandura [11]: Long-term (course) goals and goals within individual short-term learning intervals (e.g. lasting one week). The former primarily support goal-orientation and self-evaluation. It is important to allow open text answers in goal setting as well as assessment and reflection on one's progress and not limit learners to scales and dropdowns. Unfortunately, this leads to challenges in using the data for computational analysis of how well in time and value the goals were reached. Thus, short-term goals are supported to be set with an assisting form wizard that allows learners to connect goals with course topics, enter the desired skill levels and estimated time investments.

This two-level approach supports setting individual learning goals and priorities, but aligned to the preset, static course topics and content given (cf. L2).

B. Using SCRUM

Managing and structuring progress under uncertainty and changing goals is a problem that has been addressed in the field of software development earlier. Pre-structuring the whole process with intermediate goals and time estimations (waterfall model) proved to be too static and agile development models became popular. SCRUM is one of such elaborated models [12]. Primarily it consists of user stories, that represent overall goals collected in a backlog. The most important ones are focuses on within a repeating time interval, called sprint, e.g. four weeks long. The time needed to finish the tasks related to a user-story is estimated by all team members individually to come to a concise effort estimation (planning poker). Each day the progress is quickly assessed in a daily scrum meeting. When a sprint is over a review and retrospective allows to reflect over the achievements and process. Our proposed solution uses parts of SCRUM in the online learning context to support individual learners in planning their next learning interval (the sprint). The needed parts of SCRUM map nicely to the self-regulation model as shown in Table I.

TABLE I. MAPPING OF SCRUM AND SELF-REGULATION MODEL ELEMENTS

Self-regulation model part	**SCRUM model part**
Goal orientation, expectation	Backlog
(Long-term) goal	User story
(Short-term) goal	Task
Learning interval	Sprint
Time estimation	Planning poker
Self-recording	Daily scrum
Self-evaluation, adaption	Sprint review, retrospective

Time estimation during planning can be supported by calculating the accuracy of estimations of this learner in prior learning intervals and report this back as a *skill-improvement per time rate* which supports a more realistic time investment estimation (cf. L3). Self-recording during a learning interval can be supported by a wizard that provides assessment of skill level changes and time invested so far.

C. Using Peer Education

The third approach that is combined in PeerLA with the other two mentioned above, is the concept of peer education from pedagogics. We confer this to be the most innovative aspect of PeerLA as it extends the idea behind the time investment estimations from SCRUM to the possibility of social norming and orientation on other learners' set goals and levels of knowledge in the course topics (cf. L1). This is expected to support improvements on self-regulation competency, because the major problem in setting realistic (SMART) goals is a missing reference frame that gives orientation for the estimations. Specifically, for learning uncertainty about the complexity of the topics and about the amount of missing knowledge is common. The *Wise* framework for learning analytics with a focus on learners [13] proposes principles to be followed in order to prevent false interpretation and to provide data analysis assistance to learners: 1.) *Integration*: Data displaying needs to be grounded to learning activities and integrated into the learning environments, 2.) *Agency*: Learners need support in judging the data themselves and taking own conclusions, 3.) *Reference frame*: Learners need representative reference values for interpreting data. Wise highlights that average values as reference are often misleading as they are distorted by a.) inactive learners and b.) differing goals among learners. Our solution respects the principles as follows. Each learner is ranking the own level of knowledge for each area covered in the course before and after working on own learning goals (within one learning interval). Additionally, they estimate their time investments at the beginning and log the effective needed time. Such data not only allows a prediction of remaining time needed to reach an aimed level of knowledge for the individual, but also is used to calculate a similarity of learners and provide comparison to most similar other learners which are comparable in levels of knowledge, aimed levels and time investments (cf. L1 and L3).

The use of all three concepts (from computer science, psychology and pedagogy) will be explained in more detail in the following section.

III. PROPOSED SOLUTION PEERLA

PeerLA has been developed with the primary focus on online learning scenarios where course material is pre-structured into n sections (e.g. chapters) and consists of several s sources (e.g. files) and k skills to be covered within a strict time period $[x, y]$ (e.g. one semester). The simplified PeerLA learning process model is shown in Fig. 2.
Each process element has its own more detailed sub-process as described in the following.

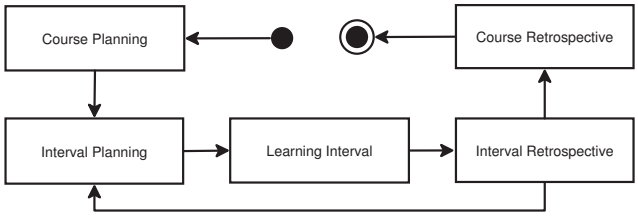

Figure 2. PeerLA learning process model

A. A two-level process to structure learning of skills

Teachers enter in the LMS the skills to be covered (usually as learning goals or similar). On first process step *course planning* learners (a.) formulate free text goals and enter their targeted course grade, (b.) they estimate their prior knowledge for each of the k skills and (c.) then map their text goals to targeted levels of skills (for a. and b. see Fig. 3 and Fig. 4).

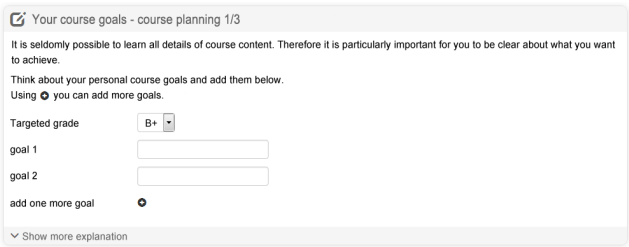

Figure 3. Targeted grade and free text long-term goals (course planning phase, step a)

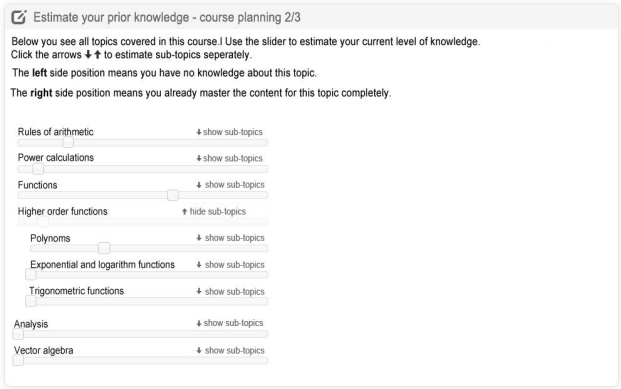

Figure 4. Estimation of skill level (course planning phase, step b.)

B. *Time investment tracking in learning intervals*

Learning interval duration is aligned with the *n* course phases, e.g. repeating lecture times mark the end of an interval (usually each week). Learners select one specific skill for a short-term goal, select one of the *s* learning resource that is available in the course (or add a new one themselves) and the activity for it (looking at, summarizing, exercising, etc.). The activities are aligned to Bloom's taxonomy of learning goal levels. Based on the selected skill, their own skill level and the selected activity a suggested value for time is displayed. It is calculated as the average of all learners similar in skill (current and targeted), skill selected and activity (see Fig. 5). Finally, learners select their learning days of the interval and estimated time needed. During the interval they can always adjust the goal status, invested time and progress in the skills (Fig. 6).

C. *Reflection on and improving of learning activities*

At the end of a learning interval learners update their interval progress finally. They are shown an overview of their long-term goals and the short-term goals worked on during the interval with a status icon (undone, in progress, done) for each. They can finally update these goals (all unfinished ones are automatically transferred to the next interval). Then can reflect over the good and bad aspects of their learning interval (using textual inputs). These are displayed on next interval planning (no figures for this in the paper).

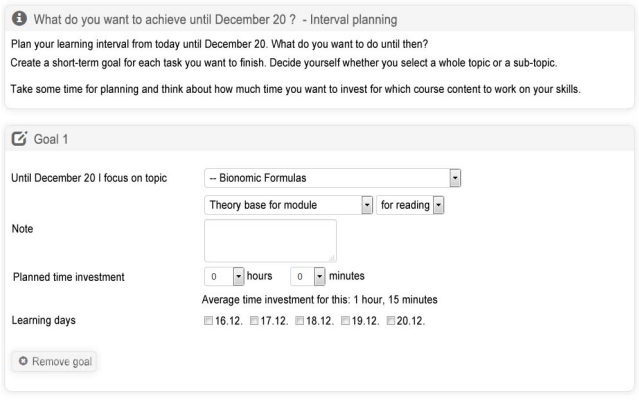

Figure 5. Setting up short-term goal(s), aligned with course skills (interval planning phase)

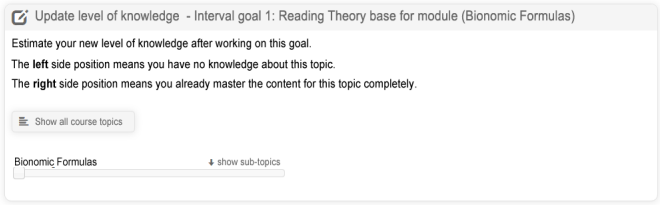

Figure 6. Adjusting level(s) of knowledge (during interval)

When the last interval is over a similar screen is shown for the overall course retrospective and the final achieved grade is entered. This is used to calculate correlation of skill improvements, time investments and activities with the reaching of grade goals. The better the correlation the more such figures influence time suggestions for next term students (not discussed in detail here).

D. *Learning analytics with social alignment*

In parallel to the process support described above, PeerLA offers an always accessible visualization of time investments and skill levels (current or targeted). The bar charts show learners own values, the average of similar users (see above description of similar) and all active learners of the course as displayed in Fig. 7.

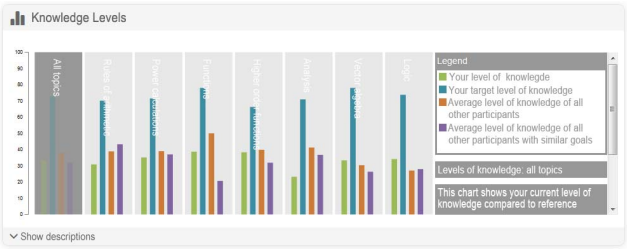

Figure 7. Peer learning analytics diagram (with legend)

This interactive chart is displayed directly below the dialogues mentioned above (respecting Wise's integration principle and reference frame). Thereby, PeerLA assists in time estimations and in social reference of levels of knowledge (current and targeted).

IV. Implementation And Evaluation

PeerLA has been implemented as a set of plugins for the LMS Moodle v2.8, because Moodle is widely used in European universities. For interactive charts and responsiveness of the user interface JavaScript libraries jQuery and D3.js are used. PeerLA integrates into common course view as a side-box and parses the course structure automatically to assist in short-term goal setting (using the available learning material) and adjusts the time interval to course dates.

For evaluation we added PeerLA to the Moodle instance of our university for the math preparation courses in summer 2015. All freshmen of natural sciences can voluntarily take this course in the four week period before their first semester starts. The course contains weekly examination tests to be conducted in order to identify one's own gaps in math knowledge. Consequently, PeerLA suggested four learning

intervals. The course does not give any grades. Thus, the PeerLA question on the desired grade could be skipped.

After the four weeks we asked them in a questionnaire about the whole math course as well two open text questions about PeerLA: *What do you consider as positive about PeerLA? What do you want to tell us additionally (improvements, Negative aspects, etc.)?* Our aim for the first evaluation was to get insight about the level of acceptance for such functionality and how useful students find PeerLA for setting (and working on) their goals. This results are expected to identify how well the concept of integrating SCRUM and peer reference data with the self-regulation model works. With these results we will conduct a deeper study in summer 2016 about intensity of usage, number of set goals and effect to self-regulation competency and knowledge gain by using an AB-test setup.

V. Results

749 students participated in the math preparation course. 83 of them responded in the PeerLA evaluation. Analysis of the evaluation answers revealed that the Moodle server was responding too slow or was completely offline for several days. Therefore, most students dropped the voluntary course. The answers to our questions were categorized in positive, neutral and negative aspects as shown in Fig. 8.

The size of answer squares is relative to frequency. 67% of the answers were positive aspects. Beside a general

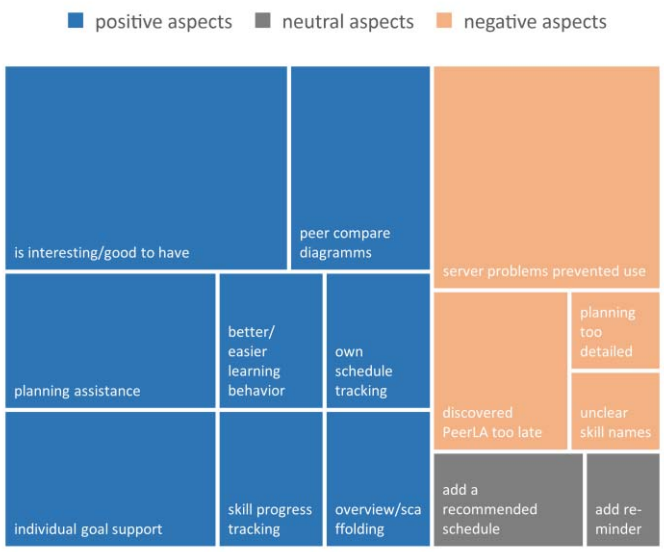

Figure 8. Treemap of categorized qualitative evaluation answers

appreciation (*good to have*), the planning assistance and possibility to set individual goals (aligned to course content) the mostly liked functionality is the comparison to other peers' knowledge level and time investment.

Only 2.3% found the planning process too detailed. For 7.1%, who discovered PeerLA too late, we will add an explicit notification of course functionality at start. For next evaluation the server outages must be addressed as they negatively influenced the results.

VI. Conclusion and Outlook

The results indicate that PeerLA is a successful approach towards learning goal planning and assistance in self-regulation for online learning scenarios. It's most innovative value comes from the combination of SCRUM model and self-regulation model with the peer learning analytics. Participants valued the visualization of skill levels and time investments to track their own progress but as well align it with their similar peers. PeerLA will be published as an open-source plugin for Moodle on http://github.com/peerla/peerla. Open questions for the planned evaluation in summer 2016 are the effect to self-regulation competency and skill improvement. Additionally, a dynamic scaffolding is planned to address different levels of existing self-regulation competency. Also, PeerLA would benefit from more research on extensive reference value calculation.

Acknowledgment

Parts of this work have been supported by Regina Bruder and Marcel Schaub from the department of Math Didactics, Technische Universität Darmstadt, Germany.

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