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Design of a Tool to Support Self-Regulated Learning Strategies in MOOCs

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Abstract: The massive and open nature of MOOCs contribute to attracting a great diversity of learners. However, the learners who enroll in these types of courses have trouble achieving their course objectives. One reason for this is that they do not adequately self-regulate their learning. In this context, there are few tools to support these strategies in online learning environment. Also, the lack of metrics to evaluate the impact of the proposed tools makes it difficult to identify the key features of this type of tools. In this paper, we present the process for designing *NoteMyProgress*, a web application that complements a MOOC platform and supports self-regulated learning strategies. For designing *NoteMyProgress* we followed the Design Based Research methodology. For the evaluation of the tool, we conducted two case studies using a beta version of *NoteMyProgress* over three MOOCs offered in Coursera. The findings of these two case studies are presented as a set of lessons learned that inform about: (1) a list of requirements to inform the design of a second version of the tool; (2) a list of requirements that could serve as a reference for other developers to design new tools that support self-regulated learning in MOOCs.

Keywords: Self-Regulated Learning, SRL, Massive Open Online Courses, MOOC, Tool, Learning Analytics, Dashboard.
Categories: K.3.1, K.3.2

1 Introduction

One of the most relevant characteristics of MOOCs is their massive number of learners. This massiveness makes it difficult for teachers to monitor learners' performance and support them in achieving their goals. In this context, one of the keys for learners to reach their goals is their capacity for self-regulated learning (SRL). Self-regulation is defined as "an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate and control their cognition, intentions and behavior, guided and constrained by their goals and the

contextual features of the environment" [Pintrich, 99]. According to recent studies, learners who are able to self-regulate their learning have greater engagement in MOOC activities [Littlejohn et al., 16] and have greater success in reaching their goals [Siadaty et al., 12] [Thirouard et al., 15]. However, learners who have less education, have difficulties in developing these types of strategies. Specifically, learners have difficulties with meta-cognitive SRL strategies—planning and organizing to reach their goals; and strategies for resource management—, time management, seeking help and organizing their study environment [Kizilcec and Halawa, 15] [Veletsianos et al., 16].

In order to support learners in the self-regulation process, the current MOOC platforms have also been developing and implementing different solutions. For instance, to encourage permanence and support learners' organization, the courses have a starting and a finish date. In addition, the MOOC platforms support certain cognitive strategies such as: reviewing the material and repeating evaluations (*rehearsal*); supporting meta-cognitive strategies through assessment activities (*self-evaluation*); viewing pending activities and progress in the evaluations with charts and calendars (*self-monitoring*); time estimated to perform activities (*time management*). The edX platform has also incorporated a functionality that allows learners to add a note to a portion of selected text (*organization*). However, according to recent research, these mechanisms seem to be insufficient in offering learners feedback on their learning process in order to make decisions about how to approach the course [Hew and Cheung, 14].

In the traditional online learning, there is a considerable body of research aimed at studying tools that support SRL strategies [Azevedo et al., 09] [Winne and Hadwin, 13] [Nussbaumer et al., 14]. However, there are few researches that propose external solutions to support SRL learning in MOOCs [Davis et al., 16] [Alario-Hoyos et al., 15]. Furthermore, within these tools, the research points out a severe weakness regarding the evaluation of existing tools leaving a gap in the measurement of the tool's impact of the self-regulatory strategies that they support [Pérez-Álvarez et al., 16] [Verbert et al., 14] [Jivet et al., 18]. The lack of solutions and results that measure the impact of the proposed tools makes it difficult to identify the design characteristics that must be considered for the development of new tools that support SRL in MOOCs.

The aim of this paper is to understand: *What characteristics should be considered for the design of an educational tool to support* learners*' self-regulated learning strategies in MOOCs?* To answer this question, this article presents the design process of *NoteMyProgress*, a web-based tool aimed at supporting learners' SRL strategies in MOOCs [Pérez-Álvarez et al., 17a] [Pérez-Álvarez et al., 17b]. This tool was designed using the Design-Based Research (DBR) methodology to consider the aspects addressed in the literature review, and it was evaluated in two case studies. Specifically, the design of *NoteMyProgress* is based on: (1) the lessons learned through the literature review process [Pérez-Álvarez et al., 16] that analyzes the main features of the proposed tools to support SRL in MOOCs; and (2) the results of two case studies conducted in three MOOCs. Section 2 presents the status of the tools proposed to support SRL and what are the most effective study strategies for MOOC learners highlighted in the literature. Section 3 presents the research methodology and describes the features considered for the design of the beta version of

NoteMyProgress. Section 4 presents the conclusions and future work. The results of this article can help designers and programmers in the development of new tools to support SRL in MOOCs.

2 Prior Work

2.1 Self-regulated Learning (SRL) and MOOCs

In the literature review on SRL, there are several models for understanding the variables that influence learners' learning [Panadero, 17]. [Zimmerman, 00] and [Pintrich, 99] models are the most widely used for studying SRL. One the main reason is that both models include a significant number of SRL subprocesses, which makes those models more comprehensive and easier to understand than other models [Panadero, 17]. In this study, we adopt Pintrich model for 3 different reasons. Firstly, differently from Zimmerman's model, Pintrich's model combines 4 phases of SRL (forethought, monitoring, control, and reflection) with 4 areas for regulation (cognition, motivation, behavior, and context). This combination of phases and areas is the basis for defining a broader group of SRL sub-processes, which facilitates the analysis of self-regulation. Secondly, these sub-processes defined by Pintrich are, at the same time, related with a set of specific strategies that students adopt while self-regulating their learning (cognitive, meta-cognitive, and resource management). This classification of strategies facilitates large-scale qualitative research and report of the relationships between learners' actions within the MOOC or technological environment and specifics strategies [Kizilcec et al., 17]. Thirdly, Pintrich model is a well-established model in the community, which have been used in prior work to study SRL in MOOCs for both, defining instruments to measure SRL in these learning environments [Jansen et al., 17] [Magen-Nagar and Cohen, 17], and to analyze how different strategies manifest in records of interaction with course content [Kizilcec et al., 17] [Maldonado-Mahauad et al., 18] [Alario-Hoyos et al., 17]. Therefore, and based on this prior work, the Pintrich model [Pintrich, 99] was selected as a suitable model for establishing a relationship between specific SRL strategies and the activities conducted by learners in a MOOC. Specifically, *NoteMyProgres* functionalities and visualizations were designed taking as a reference those strategies defined in the Pintrich model. These strategies are: goal setting, strategic planning, time management, self-efficacy, help-seeking and note-taking. Moreover, relating specific functionalities of *NoteMyProgress* with particular SRL strategies provides a theoretical basis for better understanding the relationship between learners' behavior captured within the logfiles and their self-regulated behavior.

In MOOCs, several researchers have conducted studies to understand what strategies are most effective for achieving success [Milligan and Littlejohn, 16] [Kizilcec et al., 17] [Veletsianos et al., 16]. Those studies identify *goal setting*, *strategic planning*, *time management*, *self-efficacy*, *help-seeking* and *note-taking* as effective strategies for learners who enroll in MOOCs. [Kizilcec et al., 17] identified that *goal-setting* and *strategic planning* are relevant strategies for predicting achievement of learners' individual goals. Furthermore, [Veletsianos et al., 16] found that learners use strategies beyond the learning platform, such as: taking notes, studying outside the platform, searching for information on external sources and

seeking external help to understand certain content. In another study [Milligan and Littlejohn, 16] found that *goal-setting*, *self-efficacy*, *task strategy* and *help-seeking* are the learning strategies chosen by MOOC learners. For the design of the first version of the tool, we focused on supporting the strategies of *goal setting, strategic planning strategies, time management and organization* (note-taking), because they were proven to be the most effective for MOOC learners according to the literature review.

2.2 Tools to support SRL in MOOCs

Table 1 presents 6 of the tools designed for supporting SRL in MOOCs that were published between 2008 and 2016 [Pérez-Álvarez et al., 16]. For each tool, we include a brief description and indicate what strategies are they supporting according to the Pintrich´s model [Pintrich, 99]. *Goal setting* and *self-evaluation* are the two most supported strategies. A total of 4 tools present solutions to support *goal setting*, each one following a different approach. For example, the *Learning Tracker* tool allows learners to monitor their progress in relation to the weekly goals set in the course, although the learner does not have the possibility of setting their own goals. *MyLearningMentor* proposes an interface for learners to set their own goals for each week—this tool has yet to be implemented. The *eLDA* tool allows learners to set their own learning paths, selecting the study material. Finally, in *FORGE*, learners can set their goals by selecting their own learning resources or subjects. The *self-evaluation* strategy is also presented in a different way in the tools. *FORGE* and *The Serious Game* allow learners to view an assessment of their acquired knowledge by carrying out course evaluation activities. *Learning Tracker* and *eLDA* offer visualizations of learner progress throughout the course. *eLDA*, *Video-Mapper*, and *MyLearningMentor* support *help-seeking*, as these three tools include a chat in which classmates and teachers can send messages. The first two also have discussion forums. *FORGE* and *The Serious Game* support *self-motivation* by through interactive activities (laboratories, interactive evaluations), while *eLDA* allows learners to choose the most relevant material to support this strategy. *MyLearningMentor* allows learners to plan and see the estimated workload, while *eLDA* allows learners to define their own learning path to support strategic planning. *The Serious Game* simulates a real context during the evaluation and *Learning Tracker* offers learners visualizations, so they can view and monitor their progress in the course, to support *self-awareness*. Finally, *Video-Mapper* supports *organization* by offering learners the option of taking notes on video lectures and by creating video lecture segments.

The tools analyzed in Table 1 are pioneers in offering support for SRL strategies for learners in a MOOC environment. However, these tools have certain limitations regarding the support they offer as well as the way in which they were evaluated: (1) tools such as *FORGE*, *Video-Mapper* and *eLDA* focus on a context in which the MOOC is aimed at a small group of learners, without mentioning how to support the massive number of learners; (2) some of the tools only offer support for specific areas of knowledge (i.e. energy, python programming, networks); (3) except for *MyLearningMentor* and *Learning Tracker*, most of the solutions found in the literature review only allow learners to monitor specific activities, such as evaluation activities or video lectures, without offering them the option of having a holistic vision of their behavior throughout the course; (4) most of the existing solutions have been designed to provide support for learners in a particular platform, meaning it is

difficult to adapt to other learning platforms and environments; and (5) current papers only present a partial evaluation of the tool, but do not assess the impact on learners' behavior, which some authors consider to be relevant [Verbert et al., 14] [Schwendimann et al., 17].

Tools/SRL Strategy	GS	SP	SW	SE	O	HS	TM	SM
eLDA [Onah and Sinclair, 15] is a platform that allows you to set individual learning paths. It is aimed at courses that use a blended learning method.	X	X		X		X		X
FORGE [Marquez-Barja et al., 14], is a space used to complement the course evaluation activities with interactive laboratories. It is aimed more towards blended learning courses.	X			X				X
MyLearningMentor [Alario-Hoyos et al., 15], is a mobile application that supports the planning of weekly activities.	X	X				X	X	
The Serious Game [Thirouard et al., 15], features an educational game to support evaluation activities (course in the energy field)			X	X				X
Video-Mapper [Fahmy et al., 15] allows learners to take notes, as well as create and share videos segments.					X	X		
Learning Tracker [Davis et al., 16], a widget for edX, allows learners to monitor their learning process and compare their performance against that of learners who completed the course in previous editions.	X		X	X			X	

Table 1: Tools that support SRL strategies in MOOCs. TM = Time Management, O = Organization, SP = Strategic Planning, GS = Goal Setting, SE = Self-evaluation, SW= Self-awareness, HS= Help-seeking, SM= Self-motivation

3 Methodology

To guide the design of the *NoteMyProgress* tool, we followed the Design Based Research methodology (DBR) [Reimann, 11]. This methodology mixes empirical research on education with the theories oriented towards the design of learning environments. We chose this methodological approach for three main reasons: (1) to propose a technological solution driven by educational considerations; (2) to understand the impact of those analytical frameworks and solutions in real environments; (3) for its interactive nature, to adapt to the changing field of research which encompasses this project. The phases of this methodology are: analysis, design and implementation, and evaluation.

For applying the DBR methodology we used the Interactive Learning Design (ILD) framework [Bannan-Ritland, 03]. This framework organizes the research process into 4 phases: (1) *Informed exploration*, which studies the needs, available theories and audience; (2) *Enactment*, which consists of the design of the technology; (3*) Evaluation of local impact*, which aims to analyze the impact of the technological intervention at the local level; and (4) *Evaluation of broader impact*, which considers the adoption of the technological intervention to a wider audience.

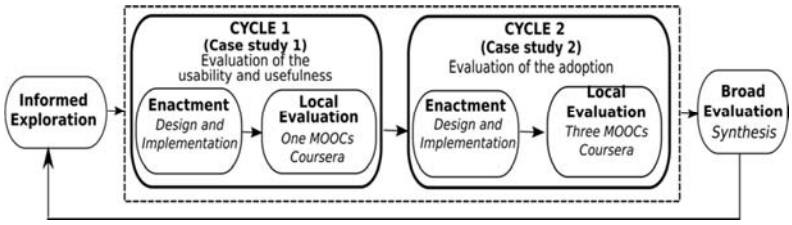


Figure 1: Cycles of the ILD framework conducted in this study

Figure 1 shows how the ILD framework was applied to design and evaluate the beta version of *NoteMyProgress*. In the phase of *informed exploration*, we conducted a literature review [Pérez-Álvarez et al., 16] to analyze the features of the current tools that SRL in MOOCs and which strategies they have supported. This phase also includes the review of literature related to the analysis of the most effective SRL strategies for MOOC learners. For the enactment phase, the tool was developed. Finally, for the evaluation phase, we conducted two case studies. Case studies offer an approach to study a phenomenon in their context and analyze the data collected in order to understand the interaction between the studied object and its context [Runeson and Höst, 09]. In this case, the object of study was *NoteMyProgress*, which was evaluated in 3 different MOOCs. The two different case studies were conducted in two different cycles in the ILD framework. In the first cycle (Cycle 1) we carried out the case study 1 to assess the usability and usefulness of the tool according with two driven questions: *RQ1. What is the level of usability of the NoteMyProgress tool in a MOOC learning environment?; RQ2. What is the perceived implementation of NoteMyProgress as a tool to support learners' self-regulation strategies?* The results of this first cycle allowed us to understand the level of usability of the tool and its usefulness in support of SRL strategies for the learners. The results of this first cycle were used to improve the version of the tool. For the second research cycle (Cycle 2), we conducted a second case study with the improved version of the tool. The objective of this cycle was to assess the adoption of the tool by learners. In this case, the research question that drive the evaluation were: *RQ3. What is the level of adoption of the NoteMyProgress tool in a MOOC learning environment?* Finally, in the *Broad Evaluation* phase, we collected the results of the previous phases in order to propose the requirements for a new tool. This list of requirements can serve also as a guide for designers and programmers to improve and propose technological solutions to support SRL in MOOCs.

3.1 Informed Evaluation Phase

The **Informed Exploration phase** consisted on analysing the results of a literature review of papers related with tools and SRL in MOOCs between 2008 and 2016 [Pérez-Álvarez et al., 16]. The literature review followed three phases: organization, completion and reporting [Kitchenham, 04]. Search process was performed on 7 data sources (Scopus, ACM Digital Library, IEEE Explorer, Google Academic, memories of eMOOCs, L@S, and LAK conferences) and three researches participated in the literature review process. The guiding question for the literature review was: *What characteristics should be considered for the design of an educational tool to support learner self-regulated learning strategies in MOOCs?* The results of this literature review set the requirements for the *NoteMyProgress* tool. In addition, we also included the articles from 2017. A total of 28 papers were revised, and 3 researchers participated in the analytical process.

As a result of the *Informed Exploration* phase, 5 key requirements were identified: **(R1) Complement existing platforms**, the design of the tool should provide support to learners in different MOOC platforms, taking advantage of the features offered on each platform and focusing on the development of complementary features aimed at supporting SRL strategies. **(R2) Supporting effective self-regulated learning strategies**, the design is aimed at offering features that support the following strategies: *goal setting, strategic planning, time management, self-evaluation and note-taking*, which have proved to be effective for MOOC learners [Milligan and Littlejohn, 16] [Veletsianos et al., 16] [Kizilcec et al., 17]. **(R3) Provide comprehensive support for learners**, studies as that of [Veletsianos et al., 16] show that learners use external resources such as taking notes, searching in other information sources, among others. The *NoteMyProgress* design should support learners while they carry out their activities, both inside and outside the learning platform. At the same time, the tool should provide support to learners in any type of course offered, without being limited to a specific area or subject, and support learners in different learning activities planned in the course. ***(R4) Provide different perspectives for information analysis***, one of the assumptions shared by most models of SRL is that it is an active process, where learners oversee their learning process [Pintrich and Boekaerts, 00]. From the perspective of an active process, learners must have the opportunity to gain a more in-depth analysis of how they are doing in their learning process. The visualizations that provide feedback to learners about their learning process must allow interaction, so that learners, according to their own objectives and needs, can monitor the aspects that are relevant to make decisions and improve their behavior. ***(R5) Offer the leaner goals, standards or comparison criteria for the analysis of their behavior***, an appropriate process of self-monitoring and control over their learning process requires learners to have goals or standards with which they can compare their performance, to assess whether their learning process should remain the same or if a certain change needs to be made [Pintrich, 99]. The design of the tool must integrate different comparison values to support the learners' self-regulated learning process.

3.2 Enactment phase

The design of the beta version of *NoteMyProgress* was designed according to the requirements extracted in the Informed Evaluation Phase. *NoteMyProgress* is a web-based tool designed to support self-regulated learning strategies for MOOC learners [Pérez-Álvarez et al., 17a] [Pérez-Álvarez et al., 17b]. It also promotes learners' awareness about the learning process and interaction within the course, so they can make decisions and adjust their behavior throughout the course. This tool has two main components: (1) a plugin developed in JavaScript, which collects information about the learners' learning activities; (2) a Dashboard developed in Ruby on Rails, which analyzes the data collected and visualizations it on graphs that help the user keep track of their activity in the course. The plugin tracks the visited URLs (on and off the learning platform) by the learners once they begin their study session on the platform. A session is defined as a set of adjacent events or visited pages whose time difference is less than a set threshold (30 minutes) [Kovanović el at., 15] [Liu et al., 15].

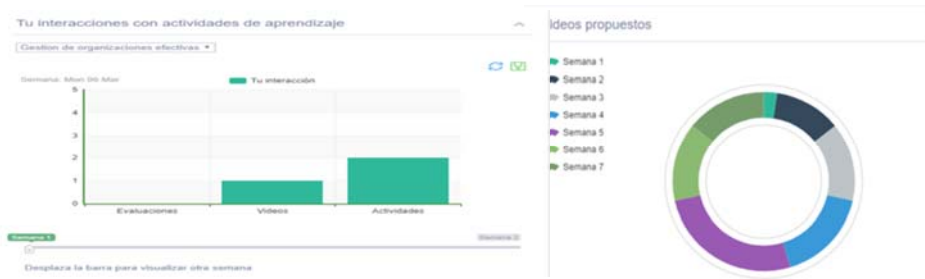
(a) (b)

Figure 2: Main Plugin Interface and Notebook of NoteMyProgress

This first version of *NoteMyProgress* was designed to complement the current MOOC platforms (R1). The Plugin component allows the learner to use our tool within any platform. However, for this first version of the tool, only support for the Coursera platform was developed. The visualizations and functionalities implemented in the tool were aimed at supporting the strategies of *time-management* and *organization* (R2). The main interface of the plugin includes a graph (Figure 2.a) that shows the time spent by the learner on learning activities (within the platform) and the time of procrastination (activities outside of the platform). The version includes a notebook (Figure 2.b) so that the learner can take notes on the relevant content. These two features also provide support for the learner within the learning platform (R3). The dashboard supports the leaner outside the learning platform (R3) and incorporates various visualizations (Figure 3) aimed at supporting the aforementioned SRL strategies (R2). In this version, we defined a set of indicators to generate visualizations that provide feedback to leaners: (1) *time spent in the platform*; (2) *time spent outside the platform* – procrastination; (3) *time spent per activity category* – videos, assessments, forums; (3) *time required per activity category*; (5) *number of different activities started per activity category, Figure 3.a*; (4) *number of activities required per activity category, Figure 3.b*. This version used

the goals proposed by the teacher in the learning activities, as a criterion for comparison of learner performance (R5).

NoteMyProgress architecture was designed to be adapted to any MOOC platform (*R1*). Specifically, a plugin was designed to be installed in the browser and thus could be used with any platform. Currently, the tool was implemented to recognize the structure of URLs on the Coursera platform, but it could be used on other platforms. The visited URLs represented the activities carried out by the learner during their study session. The learner had to enable tracking upon logging into a study session in progress. Before installing the plugin, leaners had to accept the informed consent, which explained the information that would be saved and the type of tracking that the plugin would carry out. The data collected by the plugin were constantly sent to the dashboard. The dashboard is a web application developed in Ruby 2.3.1 with Rails 5.1.3 to support leaners outside the MOOC platform (*R3*). The dashboard has several modules for data analysis; one of which is specialized in the interpretation of each MOOC platform which aims to provide support for leaners. The analysis module groups together the activities in sessions and stores them in a PostgreSQL database. For the storage of the information processed by the analysis modules, we define a learner model that integrates the collected activities of different platforms. This learner model is independent from the original data platform to facilitate the integration of the tool with other MOOC platforms (i. e. edX, Open edX…).



(a) (b)

Figure 3: examples of visualizations of the NoteMyProgress beta version

3.3 Cycle one – Case study 1: Evaluation of usability and usefulness

The objective of Cycle 1 (Case study 1) was to evaluate the usability and usefulness of the beta version of *NoteMyProgress*. The research questions used to guide the study were as follows: *RQ1. What is the level of usability of the NoteMyProgress tool in a MOOC learning environment?; RQ2. What is the perceived implementation of NoteMyProgress as a tool to support learners' self-regulation strategies?*

3.3.1 Participants, Sample and procedure

The case study 1 performed was conducted in the course "Gestión de Organizaciones Efectivas", offered by Pontificia Universidad Católica de Chile on the Coursera platform. This 7-week course was first launched in October 2015. The case study was performed only in the first two weeks of the course (week 3-4, March 2017). 4 experts (Females = 1, Males = 3) from 3 countries and 7 learners (Females = 3, Males = 4) from 4 countries (Mexico, Ecuador, Costa Rica, Colombia) participated to assess the usability of the tool. Based on the demographic data the ranges of age of the learners were 1 under 25, 3 between 25 and 35, and 3 between 36-45. 7 learners, 6 with a bachelor's degree or higher and one from secondary education. The experts group was limited to four evaluators in consideration of the suggestions made by [Nielsen, 90], who indicates that the ideal number of experts to complete an evaluation is between 3 and 5. The experts were selected for having experience in systems development, interface usability and design, and MOOCs. While, learners participated voluntarily in the evaluation. The same 7 learners participated in the usefulness assessment.

The experts were invited to participate via email. The mail was sent to 5 experts, however only 4 agreed to participate in the evaluation. The experts enrolled as learners in the course and were asked to carry out certain learning activities to feed data to the tool. The experts received a guide with the activities to be carried out, on both the platform Coursera and the NoteMyProgress tool. The learners, which enrolled during the evaluation period, were sent an email during the first week of the course, explaining the case study and inviting them to participate in the evaluation. The plugin was shared with the MOOC participants through a Google drive folder. The participants should, voluntarily, download and install the plugin manually, following an installation guide.

The usability of the tool was evaluated using a questionnaire designed according to the evaluation heuristics proposed by [Nielsen, 95]. We selected the heuristics evaluation approach because is an appropriate, efficient, and highly effective usability evaluation method in context of e-learning [Ssemugabi and Villiers, 07]. All questions followed a 5-point Likert scale, where 1 represents “Totally Disagree” and 5 represents “Totally Agree.” The average evaluation given by the students and experts for each of the Nielsen principles was calculated.

To measure learners’ usefulness perception of the tool, we designed a different questionnaire[1] addressing each functionality included in the tool. This instrument was specifically designed to get qualitative information about the main functionalities of the tool. The questionnaire is composed of 15 questions. 8 questions related with the different functionalities provided in the tool. For instances, “*The information shown in the visualizations is relevant to me”*. These questions follow a 5-point Likert scale, where 1 is “Totally Disagree” and 5 is “Totally Agree”. Moreover, the questionnaire has 2 open-ended questions asking about suggestion for new functionalities and general comments, 4 demographic questions and 1 question aimed at knowing your consent to the use of a future version of the tool.

Both, the usability and the usefulness questionnaire were delivered to the participants separately. The usability test was delivered once the participants finished

[1] https://drive.google.com/open?id=1zsFGYqA6GMTCFNlhxlFhlmfUgdARCuhU

the two weeks evaluation period. The usefulness questionnaire was delivered 2 days after completing the usability test. 20 students downloaded the tool, but only 11 completed the installation process. An invitation was sent by mail to the 11 students who installed the tool, which 7 completed the usability and usefulness questionnaires. Learners responded voluntarily to the invitation to fill out the questionnaires. In addition, 3 of the learners were also interviewed in order to learn more about their experience with the tool. And usefulness.

3.3.2 Results of Cycle 1

Table 2 summarizes the main findings of Cycle 1. At the end of the of Cycle 1, the averages usability evaluation of the tool given by the experts in all the evaluation principles were above 3,67 [Pérez-Álvarez et al., 17b]. The two principles with a lower average of evaluation were the *user control and freedom (3,83)* and the *consistency and adherence to standards (3,67).* The averages usability evaluation of the tool given by the learners' in all the evaluation principles were above 3,86. The two principles with a lower average of evaluation were the *visibility of system status (3,86)* and the *consistency and adherence to standards (3,95).* Most of the evaluation criteria regarding usefulness obtained an average of above 3,71. The criterion with the least evaluation was: *Dialog boxes -messages that show the visualizations when the mouse is over them- display relevant information (3,71).* In addition, we got the following suggestions from the experts and learners: (1) improve the *visualizations* to give clarity to the information; (2) improve the interface of the notebook; (3) optimize the response time; (4) improve interaction with visualizations; (5) add more information about their interaction with the activities; and (6) add notifications on activities to carry out for each week. As a result of the learner interview analysis, the following suggestions were obtained: (1) improve the plugin installation process; (2) expand the functionalities.

The results indicate that the experts and learners positively assess the usability of the tool. Likewise, learners considered the tool to be useful for supporting their learning process and that the visualizations are useful for reflecting on the use of time. However, one of the main problems encountered was the plugin installation process, which is a main component for learners' interaction with the dashboard. Of the 20 learners who downloaded this software tool, only 11 completed the installation process. This suggests that access and installation of the tool should be easy and intuitive for learners. Regarding the tool's design and functionality, we also detected certain limitations in the study. First, the obtained comments suggest that the tool's interface needs to be improved regarding the order of the displayed elements and content to give greater clarity to the information shown. Second, learners require the integration of additional functionalities that allow them to gain a more in-depth analysis of their learning and plan the completion of their activities.

Research Cycle	Main results regarding the *NoteMyProgress* evaluation
Cycle 1: (Case study 1) Evaluation of usability and usefulness	• It is a usable tool • It is a useful tool for learners • The installation process should be simple • The need to improve the tool interface • The need to improve the visualizations

Table 2: Results summary from Cycle 1 research (Case study 1)

3.4 Cycle two – Case study 2: Evaluation of the adoption

The objective Cycle 2 (Case Study 2) was evaluating the adoption of the *NoteMyProgress* beta version among the learners and to understand the interaction with the different functionalities. However, in this version, the tool was improved for solving some of the limitations we observed in the first plugin with the installation process. The research question used to guide the study was the following: *RQ3. What is the level of adoption of the NoteMyProgress tool in a MOOC learning environment?*

3.4.1 Participants, Sample and procedure

The case study 2 was conducted in three MOOCs: (1) Gestión de organizaciones efectivas, which has a duration of 7 weeks; (2) Hacia una práctica constructivista en el aula, which has a duration of 10 weeks; and (3) Electrones en Acción, which has a duration of 4 weeks. All courses are offered by the Pontificia Universidad Católica de Chile on the Coursera platform. This case study had a duration of 2.5 months (April, May, June of 2017). A total of 126 learners (Males = 70%, Females = 30%) from 10 countries participated in the case study carried out in this cycle. The demographic information was obtained from the data report downloaded from the Coursera platform, which provides little demographic data on students. All the learners who were enrolled during this time were sent an email in the first week of the course, explaining the case study and inviting them to participate in the evaluation. A total of 3915 learners received the invitation email.

For this cycle, the installation process and access to *NoteMyProgress* were simplified. The plugin was uploaded to the Google Web Store and learners received the link to the tool's plugin, which is installed directly from the store by pressing the install button. The method for data collection used in Cycle 2 was based on the logs generated by *NoteMyProgress*. In the analysis of the logs, the following analysis variables were considered: the *amount of entries*, *number of interactions with the different visualizations and functionalities, frequency of entries*. For the analysis of learners' interaction with the different visualizations and functionalities, we consider the three types of visualizations available in the tool (Time spent vs. Procrastination, Time spent per activity category, and Activities started). We count the number of learners' interactions with each of visualizations type. Moreover, we consider the interaction with note-taking functionality and counting the interaction number. To facilitate the understanding of the data, the data was classified according to the number of entries to the tool (1, 2, 3, 4, 5-8, 12-17). This classification allows you to

see the number of learners and frequency of entering the tool. The entries were counted as the use of the tool in different periods of time, i.e. a learner who entered and carried out several consecutive interactions, was counted as one entry. Finally, with the aim of having an overview of learners' SRL strategies proposed in the Pintrich's model, the note taking functionality was associated with the *organization* strategy; the learners' interaction with the time visualizations was associated with *time-management* strategy; and the learners' interaction frequency with the tools was associated with *self-monitoring* strategy.

3.4.2 Results of Cycle 2

Table 3 shows the results of the learners' frequency of entries to NoteMyProgress. Most students 66(52%) enter the dashboard only once and the highest number of admissions is 17.

# of entries	# of Learners	Frequency (days)
1	66 (52%)	-
2	22 (17%)	1.5
3	10 (8%)	2.5
4	6 (5%)	5
5 – 8	13 (10%)	5
12 - 17	3 (2.5%)	2.5

Table 3: Number and frequency of entries to NoteMyProgress beta version

Table 4 show the results of the interaction with the different functionalities of tool. A total of 8 learners used the note-taking feature, which created a total of 15 notes. There was a total of 196 interactions with the functionality for downloading notes, but we do not have the record of the number of notes downloaded. Although there was not extensive use of the note-taking functionality, it can be observed that the organization strategy is present among the activities that some of the students perform. To analyze the data on learner interaction off the platform, we found that on average 98% of the time used by the learners was spent on activities within the platform and only 2% was used on procrastination activities. Moreover, we have observed that learners interact with the time-management functionality and they have interested in monitoring and to know how they use their time.

Name	Type	# of interactions
Time spent vs. Procrastination	Visual	511
Time spent per activity category	Visual	459
Activities started	Visual	321
Downloading of notes	Functionality	196

Table 4: Interaction with different visualizations of NoteMyProgress beta version

The results obtained in research Cycle 2 (Table 5) show that there was a considerable increase in the number of learners who used the tool in Cycle 1 and Cycle 2, which suggests that the complexity of the installation process is an important limitation in the design of the tool. A high percentage of learners only entered the

dashboard once, which is an indicator that the information shown in the visualizations is not entirely clear or meaningful for those learners. However, we noted that about 30% of learners had an interaction equal to or higher than three interactions with an average time frequency of 4.5 days. This indicates that learners connect or monitoring their learning at least once a week. Learners' interaction with the *NoteMyProgress* dashboard denotes the use of self-monitoring strategy, which allows students to monitor their performance in the course. There is a low use of the notebook; this data agrees with the suggestions obtained in Cycle 1 on improving the notebook interface. Considering the results of Cycle 2, we can obtain some conclusions for the definition of new requirements. First, learners require more information about their learning process that motivate the regular use of the tool. Second, the factor of time is an important component of the process of monitoring the learners. Finally, learners to perform activities related with Pintrich's strategies, such as self-monitoring, time-management and organization.

Research Cycle	Main results regarding the NoteMyProgress evaluation
Cycle 2: (Case study 2) Evaluation of the adoption	• Many learners interact just once, due to a lack of clarity and to the relevance of the information displayed. • There was an increase in adoption regarding the number of learners who used the tool in cycle 1. • The average frequency of learner's entry was 4.5 days. • The greatest interaction occurred with visualizations that show information on time spent. • Learners perform activities related with Pintrich's strategies such as self-monitoring, time-management and organization

Table 5: Results summary from Cycle 2 research (Case study 2)

3.5 Broader Evaluation

In this section we will provide a summary of the results obtained in the two research cycles to offer a broader evaluation of the best approach for the design of *NoteMyProgress*, and to maximize the impact on the self-regulation strategies of MOOC learners. From the evaluation results of the *NoteMyProgress* beta version, we obtained the following list of requirements that we believe should be taken into account for the design of a tool that supports self-regulation in MOOCs.

The first requirement is the design and implementation of a **usable tool** to assist the learner in understanding the feedback information shown by the tool. The installation process and access to the tool to should consider the diversity of learners enrolled in the MOOCs. In addition, the tool interface must be standardized and organized to facilitate navigating and understanding of the information.

The second obtained requirement is that we should create an **organization of indicators** to improve the visualizations and provide greater clarity to the feedback information shown on the tool. Table 6 shows our proposal of indicators organized into three categories, which were defined considering the literature review and the results of the two case studies. The categories are: *engagement*, *performance* and *effectiveness*. *Engagement* is the follow-up activities that show learner interaction within the course. *Performance* is a follow-up to the activities that allow you to view

learners' progress during their learning process, including the attainment of personal goals set by the learner. *Effectiveness* is a follow-up to the activities which allows you to view the periods in which learners have better performance. A subcategory added in *NoteMyProgress* for the display of indicators is the management of sessions. Learners can view their behavior grouped by study sessions. Each of the indicators was associated with SRL strategy that can be supported by that indicator and some visualizations. The association of indicators regarding the strategies was based on the definition of each strategy of the Pintrich model.

Finally, the third identified requirement is that the tool should be equipped with **robust and interactive visualizations.** The interactive component added to the visualizations allows the learner to have the option of attaining a more in-depth analysis of their behavior and focus on the most relevant points according to their goals and personal needs. We propose a new set of interactive visualizations (Figure 4) organized according to the classification defined for the different indicators. In addition to interactivity, the design of the visualizations allows learners to analyze information from different perspectives and time periods: session, activity category, day, month, or view a general outline of the learning process until the current week. Different goals and standards for comparison were also added, which support the learners' monitoring process. First, we incorporated the goals set defined in the course (number of required activities and time required to spend). Second, we added the option for the learners to set their own goals (number of videos to watch, number of evaluations to be carried out, time to spend, day planned for studying) and we displayed the comparison between the targets and the attained goals. Finally, we integrated a functionality that provides learners a comparison of their performance with the rest of the learners in the course with data from previous courses. Social comparison has shown to have a positive effect on learner engagement and efficiency [Brusilovsky et al., 15].

These requirements were used for the design and implementation of a new version of NoteMyProgress. An improvement is also proposed for the visual appearance of the notebook, and a WYSIWYG (What You See Is What You Get) - type editor will be added to offer editing facilities and encourage the use of the notebook.

Type	Indicator	Description	Strategy supported
Engagement	time spent (course, session, category, procrastination)	time spent summarize	TM
	number of sessions	number of sessions achieved.	TM
	time required	total time estimated by the teacher to each category.	TM
	weeks on the course	number of weeks spent.	TM
	study frequency	average time among sessions.	
	notes took	number of notes taken in the course.	O
Performance	activities completed	number of different activities completed.	TM, SE
	activities started	number of different activities started.	TM, SE
	activities attempted	number of different activities attempted.	TM, SE
	activities required	number of activities proposed by the teacher.	TM, SE
	videos planned to watch	number of videos planned by the learner to watch during the week.	SP, GS
	time planned to spend	time planned by the learner to spend during the week.	SP, GS
	evaluations to be taken	number of evaluations planned by the learner to do during the week.	SP, GS
Effectiveness	most effective day	day of the week and time of the week in which most activities are completed.	TM, SP

Table 6: Types of data collected, indicators and strategies supported by each indicator. TM = Time Management, O = Organization, SP = Strategic Planning, GS = Goal Setting, SE = Self-evaluation

4 Conclusion and future work

This research was conducted with the aim of presenting the design and evaluation process of *NoteMyProgress*, a tool designed to complement the current MOOC platforms and support learners' SRL strategies in MOOCs. We present the design and evaluation process followed for the beta version of the tool and also provide a list of requirements obtained as a result of the process for the design of a new version of the tool.

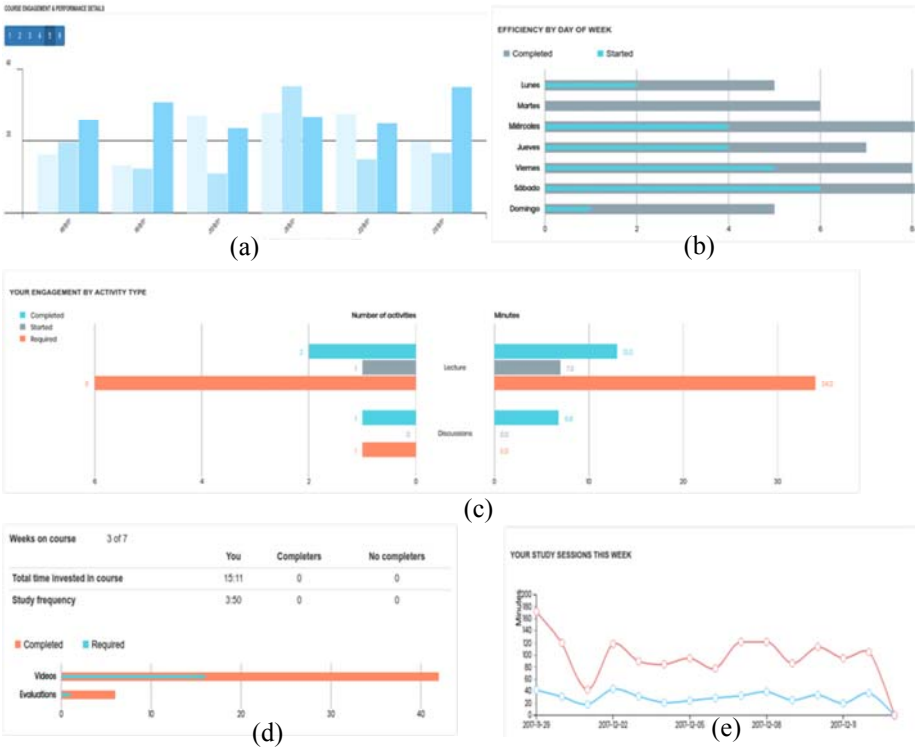


Figure 4: Examples of visualizations proposed for the new version of NoteMyProgress

The main conclusions of the design process suggest that a tool to support SRL in a MOOC must have the following requirements: (1) be a usable tool; (2) organize the indicators to be displayed; and (3) design robust and interactive visualizations. These requirements can be used as the basis to propose alternative designs for the support of SRL in MOOCs. As an example, and in order to propose an operationalization of these requirements, this article has presented the beta version of *NoteMyProgress*. Currently, a new tool is being worked on to improve the current version, taking into account the identified requirements. In addition, considering the results of the process followed for the design of *NoteMyProgress* we extract the following recommendations: (1) before starting with the design of the tool, it is important to adopt the model of SRL to be taken as a reference for guiding the design process; (2) in the first design of the tool it may be difficult to support all the self-regulatory phases or strategies proposed in the selected models, therefore it would be necessary to prioritize and focus on those self-regulatory strategies which were shown to be most useful for the students in the context of study; and (3) to associate students' learning activities with different strategies or phases of self-regulation, this association will allow a better definition of the functionalities, indicators, visualizations and metrics for the evaluation of the tool and measure its impact.

This study presents the following limitations: (1) learners participation in the use and evaluation of the tool design is voluntary, which may lead to self-selection bias in the results obtained; (2) we conducted an exploratory study to learn the perception of experts and learners about the usability of the tool as well as the perceived usefulness of the tool for the learners, but the study does not allow us to report results on the impact of the tool on the self-regulation of the learners. Future work includes designing an experimental setting that assures a randomized sample of participants, and an analysis of what is the impact of the tool on learners' behavior.

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