Small Private Online Courses in Computing Learning: evidence, trends and challenges

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Abstract. *SPOCs (Small Private Online Courses) are considered a variation of MOOCs (Massive Open Online Courses) and intend to facilitate the combination of online resources and technologies with personal engagement between disciplines and learners. The goal of this paper is to provide both an overview and a discussion about SPOCs' trends, benefits and challenges in the scope of Computing teaching. For that, a systematic mapping of literature (SML) was performed. The benefits and challenges pointed out by selected papers are grouped and analyzed in four different perspectives: students, industry, teachers and Higher Education Institutions. The results show how SPOCs have been applied and it is discussed how these resources can be helpful in Computing teaching.*

Resumo. *Os SPOCs (Small Private Online Courses) são considerados uma variação dos MOOCs (Massive Open Online Courses) e pretendem facilitar a combinação de recursos e tecnologias online com envolvimento pessoal entre disciplinas e alunos. O objetivo deste artigo é fornecer uma visão geral e uma discussão sobre as tendências, benefícios e desafios dos SPOCs no escopo do ensino de Computação. Para isso, foi realizado um mapeamento sistemático da literatura (MSL). Os benefícios e desafios apontados pelos trabalhos selecionados são agrupados e analisados em quatro diferentes perspectivas: estudantes, indústria, professores e Instituições de Ensino Superior. Os resultados mostram como os SPOCs são aplicados e é discutido como esses recursos podem ser úteis no ensino de Computação.*

1. Introduction

SPOC (Small Private Online Course) is a model that combines online learning with the traditional classroom on a small scale. Commonly, SPOCs are used to support face-to-face classes or can be also applied in conjunction with teaching methodologies such as flipped classroom [Mutawa 2016]. The concepts and learning resources to support the curricular program of SPOC are similar to those of MOOCs (Massive Open Online Courses). They also include videos, assignments, evaluations, reading materials, discussions and other resources.

The goal of this paper is to provide a discussion on how SPOCs have been applied to Computing learning context. In addition, an analysis was performed of their benefits, trends and challenges for those who intend to integrate this approach

in their classes. Those trends, evidence and challenges were identified after conducting a systematic mapping of the literature (SML), following the protocol proposed by [Kitchenham and Charters 2007].

The selected studies were grouped in 4 different perspectives: students, industry/private sector, instructors/teachers and Higher Education Institutions. The results indicate the benefits and challenges in the application of SPOCs in several fields, with emphasis on Computing subject areas. The remainder of this paper is organized as follows. In Section 2 it is presented the background of SPOCs. The research method, used in the systematic mapping, is described in Section 3. In Section 4, SPOCs' trends, challenges and advantages are addressed and discussed. Finally, Section 5 contains the conclusions.

2. Small Private Online Courses

The concept of SPOCs (Small Private Online Courses) was initially proposed by [Fox 2013], who combined classroom and online teaching. The first SPOC was implemented as a new teaching experience; teachers have distributed videos and other resources to students as homework assignments. Then, the knowledge assimilated by the students were complemented in the classroom.

[Fox 2013] says that MOOCs (Massive Open Online Courses) can be used as additional material for traditional classroom teaching. SPOCs apply the concepts of MOOCs in private courses, which the large differential is the size of the population [Kaplan and Haenlein 2016]. They are designed to meet a small number of students [Muñoz-Merino et al. 2017], which makes possible the teacher-student and student-student interactions to be expanded [Zhou et al. 2016].

SPOCs have the size of a traditional classroom, limiting the number of students to tens or, at most, to a few hundred [Mutawa 2016]. With the small number of students, the individual learning process can be emphasized, evaluating their growth [Li 2016]. In addition, communication is optimized, so teachers and students can exchange messages with each other easily [Bian 2016]. However, only a group of people enrolled in the course can access it [Mutawa 2016].

SPOC is a hybrid model for integrating online learning with the traditional classroom on a small scale. Commonly, they are used to support face-to-face classes or can be also applied in conjunction with the flipped classroom methodology [Mutawa 2016]. Students access videos and reading materials in the SPOC. Then, they go to the classroom to discuss and solve problems under the guidance of a teacher or instructor. Teachers have an important participation in the learning process of students, answering questions and promoting discussions [Zhou et al. 2016].

3. Methods

Aiming at investigating trends, advantages and challenges of SPOCs application, a Systematic Literature Mapping (SLM) was conducted. Through the conduction of this mapping it is possible to evaluate and interpret all relevant studies for a research question or topic. The followed protocol was divided into stages suggested by [Kitchenham et al. 2005]: planning, conducting and publishing the results.

3.1. Planning

Through this mapping, the trends, advantages and challenges of SPOCs' application were investigated, with the main objective of characterizing this type of application through the analysis of scientific publications. At the end of the mapping, the following research questions were discussed:

- Q1: How are SPOCs being applied ?
- Q2: In which domains are SPOCs being applied?
- Q3: In which Computing domains are SPOCs being applied?
- Q4: What benefits can be identified in SPOCs deployment?
- Q5: What challenges can be identified in SPOCs deployment?

The search string was defined from SPOC term and its synonyms concatenated by logical operators: ("SPOC" OR "Small Private Online Course" OR "Small Private Online Courses" OR "SPOCs"). This string was applied in electronic databases, in which the primary studies were searched and extracted for reading and analysis.

Finally, the criteria for selecting primary studies were established. The returned publications were analyzed in compliance with parameters of inclusion and exclusion. In that way, it was possible to select only relevant publications to the present work. Publications discussing or describing application of SPOCs by HEIs (Higher Educational Institutions) were included. Duplicate publications and papers that are not written in English were excluded.

3.2. Conducting Stage

The conducting stage began with the primary studies identification, subsequently the search string was applied to the chosen electronic databases. As a result, 1706 scientific publications distributed among the five bases were returned. After, the stage of pre-selection occurred. This stage consisted in reading title, summary and keywords aiming at evaluating whether the publication is relevant or not to solution of the research issues.

During this phase, duplicated publications were also excluded. The pre-selection resulted in 169 primary studies, which were fully read, applying the filtering criteria defined in the protocol. At the end, 49 primary studies were selected. After the identification and selection of the primary studies, the data was extracted and synthesized. The result of the synthesis, as well as the answers of the research questions, are be presented in the following section.

4. Results

SPOCs' applications were analyzed in the first research question. Hybrid teaching it is the higher incidence in which SPOCs are applied. In this teaching methodology, SPOCs are used as extra-classes activities in conjunction with traditional methods in undergraduate courses. They can also be applied with pedagogical models, such as flipped classroom.

In distance learning, SPOCs are applied in lieu of traditional teaching, i.e. undergraduate and graduate disciplines are offered using this type of course. They also are used as introductory courses of some discipline in which are required (or desirable) prerequisites. An example, is the use of SPOCs as review of Mathematics, Chemistry or Physics concepts for freshmen in Engineering courses [Kloos et al. 2014]. Finally, there

is the possibility to use the SPOCs as a complement to the traditional classes, providing support to undergraduate disciplines.

The analysis of the second research question was performed from the perspective of the knowledge areas in which SPOCs were applied. As illustrated in Figure 1, there are a variety of areas that apply or discuss SPOCs application, with prominence for Computing, Chemistry, Physics and English teaching.
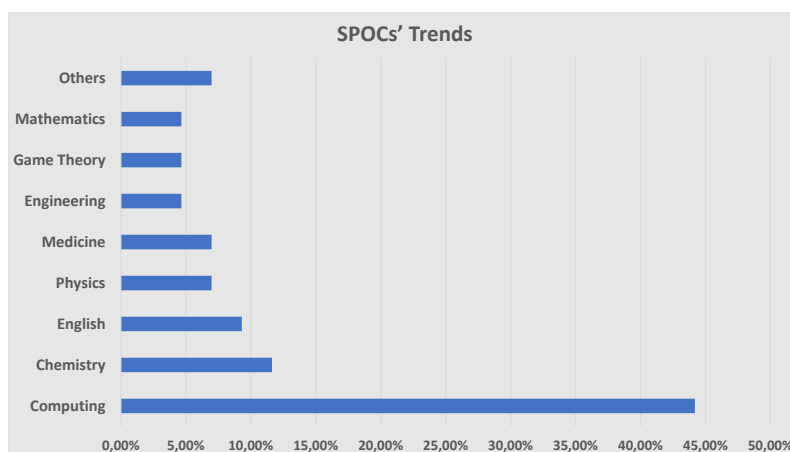

Figura 1. Representativeness of the field of SPOCs

The analysis of the third research question explores Computing subareas. The subareas in which SPOCs have been applied are presented in Figure 2. Most of the studies is about programming language and computer principles teaching. Also, studies in software engineering, computer network, data structures and algorithms were found, showing the variety of computing topics that SPOCs are applied.
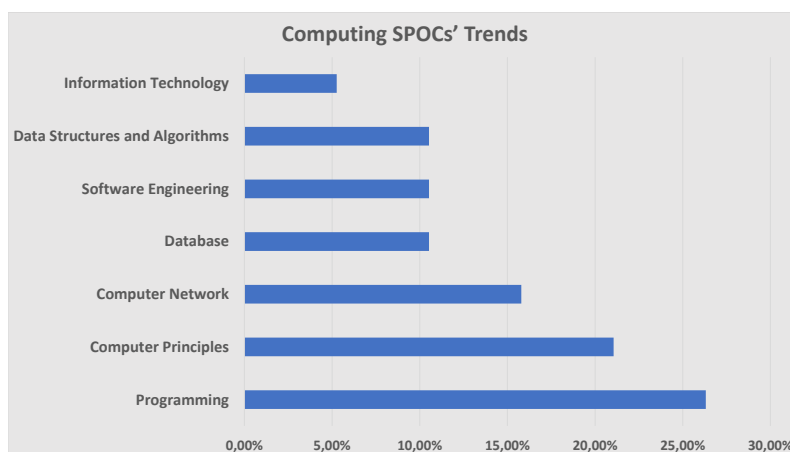

Figura 2. Representativeness of the field of Computing SPOCs

Studies about hybrid and blended learning have been performed in courses such as Database Technology and Application [Sui 2017], Information Technology and Teaching [Cheng and Zhang 2014], Computer General [Chen and Zheng 2017]. In these scenarios, students follow their SPOC and present themselves for the proctored exams or face-to-face lectures.

Many studies apply flipped classroom, for instance in Data Structures and Algorithms [Zhang et al. 2015] [Martínez-Muñoz and Pulido 2015] or programming [An et al. 2017]. Generally, students are asked to review the SPOC resources (videos, lectures, texts) before classes. At classroom time, teachers checks if students have understood the concepts presented in the SPOC. After, a task that requires to apply the learned concepts is given to students. During the task execution, teachers help them by answering questions and resolving doubts. Tasks can be project development or a set of exercises in which students code small programs. Later, the solutions to the tasks can be explored by teachers.

SPOCS are also integrated into programming teaching, training students before programming assignments, [Chu et al. 2015]. In this approach, students can write and run their programs in the browser. In addition, gamification elements can be inserted, awarding virtual badges to students, as far as they accomplished the quizzes and assignments [Kloos et al. 2014] [Piccioni et al. 2014].

SPOCs application practices are illustrated in the Figure 3. In distance learning approaches, questionnaires (at the beginning and the end of the course), online learning behaviors (in the form of clickstream or video visualization) and test scores are collected and analyzed. Among the issues analyzed are the students' previous knowledge, the effort and time spent with the course, the quantity of assignments every week and SPOC resources. On the other hand, in hybrid approaches, students complete the course content learning before the class, where the practical assignments and the exchanges between teachers and students happens. After classes, the process evaluation is conducted.
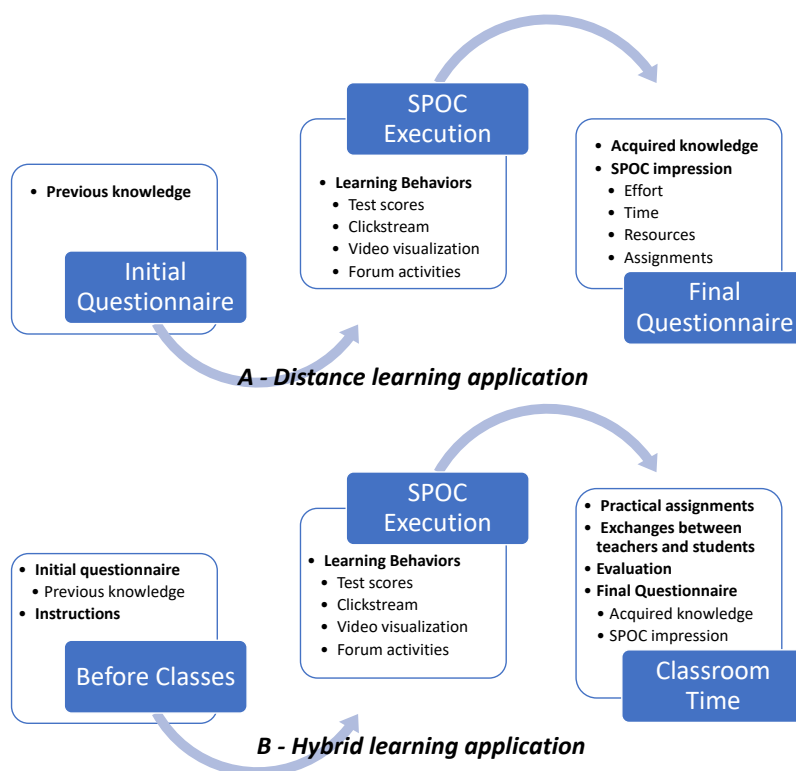

Figura 3. SPOC Application Practices

The fourth and fifth research questions, that explore the SPOCs' benefits and challenges found in this mapping, were answered through different points of view: students, instructors (or teachers), private sector (Industry) and HEIs. However, some of the pointed out benefits and challenges may fit into more than one group.

4.1. Advantages from Students' Point of View

Most of the advantages from the students' point of view are related to the ratios between the application of: (i) SPOCs and MOOCs; (ii) SPOCs and traditional methods of teaching. Comparative studies evaluate the students' performance in traditional methods of teaching and hybrid methods using SPOCs, analyzing the teaching effect after the SPOC application. The results indicate that the best performance of students is achieved with the use of SPOCs. Besides, SPOCs' resources can improve the classroom teaching [Li 2016].

The independent learning provided by SPOCs contribute to students' interest and motivation. During the process of self-study, students develop the ability to acquire knowledge and skills [Lu 2018]. The networking among the students is part of the knowledge acquisition process. During the execution of the SPOC, students spend more time discussing via forum and create collaboration networks, contributing to a collective learning.

SPOC resources, such as forums, reading materials, and especially videos, are important in the student learning process. The use of videos allows students to review the concepts that they consider complex or difficult to understand at any time, especially after face-to-face classes. Students can replay online videos on their own time, pace of learning, and make questions towards the course [Guo 2017].

The application of SPOCs also provides a better balance between theory and practice. Generally, theoretical concepts are seen in a SPOC. Students and teachers can make an efficient use of classroom time by means of hands-on activities. Through SPOCs' interactions, students improve not only their ability to co-operate, but also their communication skills. The students' communicative competence is developed during the practical activities and the discussions promoted in the forums. Besides, online communication discussion helps students change passive acceptance of learning [Guo 2017].

Studies that compare the performance of participants in MOOCs and SPOCs point out that the best results are obtained in SPOCs [Muñoz-Merino et al. 2017]. In addition, some comparative studies analysis the commitment of participants in MOOCs and SPOCs point out that the best results are achieved in SPOCs, especially in cases where HEI's allow to use SPOCs as academic credits [Song, Qiang-Ping et al. 2016].

4.2. Advantages from Private Sector Point of View

Partnerships can also be established between institutions of education and private sector, in which companies can employ SPOCs in substitution or complement of traditional trainings. SPOCs also have production costs, for this reason, the incentive to include the private sector is important in fund raising [Wendt et al. 2016].

4.3. Advantages from Instructors' Point of View

SPOCs provide the use of teaching strategies such as flipped classroom or blended learning. So, teachers use the classroom time to solve problems and promote discussions

aimed at promoting active learning [Alario-Hoyos et al. 2017]. In addition, the integration of online and offline teaching is promoted, allowing the reform of teaching methods and student-centered learning.

The supervision and interaction between students and instructors are easier than in a MOOC due to the smallest number of participants in SPOCs [Song, Qiang-Ping et al. 2016]. SPOC environments provide students the opportunity to obtain more information from the instructors, providing collaborative learning [Jong 2016]. The role of instructors is crucial for the SPOC success, they must monitor and encourage students to devote more effort in learning assignments.

SPOCs are composed by learning resources which can be personalized according to the students' characteristic and cognitive style, satisfying their individualistic learning needs [Lu 2018] and increasing the assignments completeness rate. Studies indicate that there was an increase in the rate of delivered assignments by the students [Lu et al. 2016]. Furthermore, SPOCs can provide data for learning research. The interaction and evaluation procedures provide a lot of data for teachers and researchers [Lu 2018].

4.4. Advantages from HEIs' Point of View

Generally, SPOCs provide a positive experience for those involved [Juan 2017]. After the end of the SPOC, reports and surveys point out high approval ratings by the participants. Good approval rates imply in a low dropout rate. For instance, SPOCs completion rates are higher than the rates achieved by MOOCs [Muñoz-Merino et al. 2017] [Song, Qiang-Ping et al. 2016]. The factors influencing these rates are the reduced number of participants and the use of credits, motivating students attending the class.

4.5. Challenges from Students' Point of View

Students must become autonomous learners, so they must show motivation and proactivity in the course [Kaplan and Haenlein 2016]. Instructors must develop motivation strategies for students, which can also be considered a challenge for instructors, making good use of class time to carry out activities and promote discussions which add value to the content available in the SPOC [Alario-Hoyos et al. 2017].

Usually, SPOCs have assignments that students must deliver each week. However, some students cannot submit these assignments in time. In addition, the use of SPOCs requires adaptation of students accustomed to traditional teaching methods.

4.6. Challenges from Private Sector and Instructors' and Point of View

According to [Wendt et al. 2016], the main challenge faced by the private sector is related to the formalization of partnerships. Agreements between private sector and HEIs must be formalized in accordance with HEIs' institutional rules.

From instructors' perspective, SPOCs promotes the shift of roles and everyone involved need to be prepared to accept new concepts [Wang et al. 2016]. For instance, teachers are not transmitters of knowledge any more, they are designers and must conduct the teaching activities [Juan 2017]. However, some teachers may face difficulties applying online teaching resources.

SPOCs have a reduced number of participants, which requires an active and constant participation of the instructors. In addition, teachers need to make good use of classroom time to carry out activities and discussions which add value to what is already available in the SPOC [Alario-Hoyos et al. 2017] Also, it is necessary to define the methods of evaluation. For example, the evaluations could be performed individually or in pairs. In the case of adoption of cooperative activity evaluations, they must be well defined.

4.7. Challenges from HEIs' Point of View

The creation of SPOCs resources need be supported by HEI's, that must provide all the required support. Teachers must be provided with the best practices and tools for creating learning materials. Human resources must be available to assist teachers in the development of the SPOC [Muñoz-Merino et al. 2017].

The definition of the course learning objectives is an important step in the planning of a SPOC. The skills acquired by the students, as well as the plan of their realization should be defined and available to participants. HEIs should design courses that stimulate the discussion and interaction among students, aiming to avoid the individuality of these participants [Filius et al. 2018].

5. Conclusions

In recent years, the use of technology to support teaching has been spreading. Following this trend, the MOOCs and, more recently, the SPOCs have arisen. However, the SPOCs are resources that have been still little explored in Computing area. Few works describing their applications in Computing context were found in the literature. In addition, there are no mapping studies that summarize the benefits and challenges of their application.

This paper presented a systematic mapping of the advantages and challenges of applying SPOCs. The results show that instructors can take advantages of SPOCs' features, like online videos and evaluation mechanisms to provide students new learning experiences. Unlike the MOOCs, the SPOCs are courses with a small number of participants, in which students usually watch the videos before face-to-face classes.

In this sense, it is provided a higher interaction between instructors and students. During the classroom hours both have more opportunities to develop learning experiences through groups discussion, hands-on assignments, project-based learning activities, simulations or experiments. Finally, it is noted the potential of the exploitation of SPOCs in several areas, due the features that can be incorporated into classes, providing the combination of theory and practice.

The results of the systematic mapping in this study show a trend of SPOCs application in Computing teaching, in which the programming and computer principles stand out. However, there are also applications in computer network, database, software engineering, data structures and algorithms. In short, MOOCs and SPOCs are course models that can used in Computing learning. MOOCs are recommended in large-scale education. On the other hand, SPOCs are ideal to be applied along in Computing subject areas or during online training courses to update industry practitioners.

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