Let us learn together!

Do complementary abilities foster pair collaboration in web-based learning?

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***Abstract*— Information and Communication Technologies (ICT) is playing an increasing role in our daily lives and it is changing the way of delivering knowledge. For engineers and related careers, where new trends and technologies are delivery continuously, having professional success depends on being updated with them. By adopting web-based learning for that both, students and professionals may speed up such achievement. Nevertheless, the dropout rate of courses delivered through the World Wide Web (Web) use to be very high, mainly the ones delivered through MOOC (Massive Open Online Courses). Reasons for that rely on several causes, mostly the ones related to the students' difficulty of adapting themselves to the routine of individual studies. Therefore, finding strategies to deal with this difficulty may mitigate dropout rate in web-based learning. In this paper we describe a systematic review of the literature to find evidences of the relevance of proposing a model to support web-based courses and foster collaboration between pairs as a mean to address the top three problems identified as reasons for high dropout in distance learning. We also sketch iMPaCTS, the resulting model.**

Keywords*— *web-based learning; dropout; systematic review; pair collaboration; iMPaCTS.

I. INTRODUCTION

The advances in *Information and Communication Technologies* (*ICT*), associated with the specific evolution of the technologies relate to education, has leverage the usage of distance learning modality. This movement has democratized the learning, turning the knowledge accessible as never before. Using these technologies, several traditional educational institutions had started certificated courses under the modality of distance learning.

The last trend in this learning dissemination was the so called *Massive Open Online Courses* (*MOOC*) [1]. They started in 2008 and became very popular after 2012 [2]. In this type of course, the content is available over the Web, and the enrollment is free of charge and no limited. For this reason, a typical MOOC must be self-regulated, with no tutors.

Despite their growing presence, the literature has pointed out a critical question, the high dropout rate in courses delivered through the World Wide Web (Web) [3][4][5][6]. Reasons for that rely on several causes, mostly the ones related to the students' difficulty of adapting themselves to the routine of individual studies [3][4][5][6]. Therefore, finding strategies to deal with this difficulty may mitigate dropout rate in distance learning, especially when considering MOOC as the modality for delivering distance learning. It's our claim that when learners work together with someone who has complementary skills, the learners motivate themselves and produce better. In order to find evidences that such a claim could be the starting point for a research question and the proposition of a model to support (web-based) learning based on pair collaboration, we had conducted a systematic review of the literature from the last 8 years.

The goal of a systematic review (SR) is providing a general view of an area or topic of investigation and determining evidences to the research based on wide scope exploratory questions [7][8]. The protocol to guide the SR, was composed of: (i) research question; (ii) search strategies; (iii) selection; and (iv) data extraction and analysis. Also, the SR was conducted iteratively, beginning with a wide scope question related to the dropout rate and its results guiding us to define a new question for which the protocol was applied and so on, until we had enough evidences to define iMPaCTS, a Model for Pair Collaboration Tool support. The steps to define the model are: (i) adapt an agile method to the process of teaching and learning through the Web; (ii) define a diagnosis technique to assess students' knowledge and abilities; (iii) considering complementary knowledge, define a strategy for pair formation; and (iv) define criteria for pair assessment. In this paper we describe the systematic review and the collaboration model aforementioned.

II. CONDUCTING AN ITERATIVE SYSTEMATIC REVIEW

In order to establish the basis for providing an approach to address the problem of high dropout rates in distance learning (DL) courses we had conducted a systematic review following an iterative approach.

A protocol was defined to guide the review, and it was composed of: (i) research question; (ii) search strategies; (iii) selection criteria; and (iv) data extraction and analysis (see **Fig. 1**). Considering the iterative approach, the idea was running the protocol once for one general question and considers its results to guide the definition of new research questions to run the protocol again. This is repeated until no new relevant evidences were found.

The review was made applying the protocol considering the following basis: IEEE Xplore, Google Scholar, Computers & Education (journal) and the Brazilian Committee of Informatics and Education related publications. It was considered literature written in English and Portuguese.

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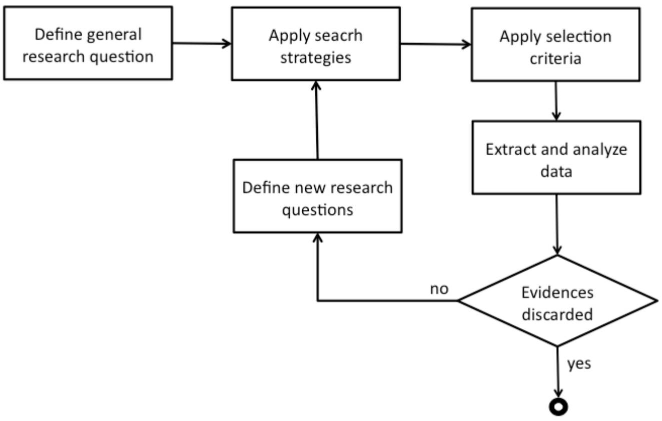

Fig. 1 Systematic Review: an iterative approach

A. Running the protocol

The first research question (RQ1) we define was a general one, to search for the causes of high dropout in distance learning. Explicitly,

- RQ1: Which are the causes for high dropout in DL? What are the proposed solutions to deal with it?

Having defined RQ1, we started defining what should be the search strategies that must be carried on to find relevant literature about the theme. As a result, we decided to (i) conduct text mining within the repository of CEIE, the Special Committee for Informatics in Education of the Brazilian Computing Society; (ii) conduct searches within IEEExplore and Google Scholar; (iii) conduct search within the Computers & Education journal. Also, we had established as time interval to conduct the search the years of 2008 to 2015 in order to recover updated research about the theme.

The CEIE repository is composed of publications related to the Brazilian Symposium on Informatics in Education, the Brazilian Journal on Informatics in Education and the Brazilian Workshop on Informatics in Education, and most of these publications are written in Portuguese. Since we had established a time interval for mining such publications, we decided to locally import all the publications from the considered period and conduct the text mining using RapidMiner[B]. There were 1995 publications to be mined and the software identified 29 that should be somehow relevant for RQ1.

For conducting the search in other basis, we extracted keywords, both in Portuguese and English, from RQ1 in order to define search strings to use in each base search engine to find literature on the issue. Thus, the reference search string for RQ1 was *("dropout rate" AND ("distance learning" OR "distance education"))*.

As a result, Google Scholar recovered 8359 documents, IEEEXplore recovered 62 documents and Computers & Education recovered 60 documents. Having all the results from the first search strategy, we defined a process for selecting, extracting and analyzing the documents recovered, to find evidences that were applied to our problem.

A process for selecting and extracting which results from the text mining and the search engines would be relevant for our research was defined and showed in **Fig. 2**. After applying the process, from CEIE, 24 were included and 14 were considered relevant; from Google, 50 were included and 37 were relevant; from IEEEXplore, 10 were included and 3 were relevant and, finally, from Computers & Education, 10 were included and 6 were relevant, in a total of 60 relevant documents for RQ1.

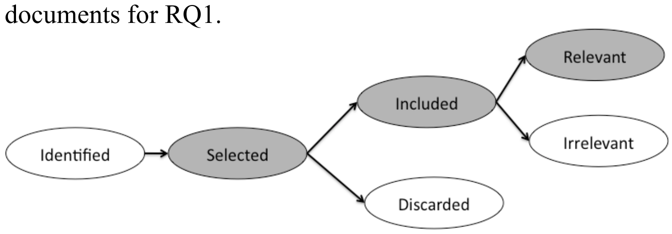

Fig. 2 Selection, Extraction and Analysis Process for the Systematic Review

In the selection, extraction and analysis process, for identified we meant all the results that were returned by RapidMiner or the search engines; for selected we mean the top 5 publications according to the search engine relevance for each year of publication, or all if there were less than 5 results for that year. For text mining, all publication identified by the RapidMiner were selected. Selected publications were analyzed according their availability (if not available they were excluded from the list and the next was considered) before reading their titles and abstracts to find some relation to the RQ. The ones considered somehow related were included in our list and the others were discarded. All the included publications were entirely read and then we decided which ones were relevant. At the end of the process, from 94 publications included, 60 were considered as relevant for RQ1. After reading the 60 papers, we analyzed how RQ1 has been addressed in the last years.

The references that somehow addressed this question are: Almeida (2008) [9]; Almeida and Ildete (2008) [10]; Alves and Pereira (2012) [3]; Baggi and Lopes (2011) [4]; Bastos and Silva (2010) [11]; Bittencourt (2011) [12]; Bittencourt and Mercado (2013) [13]; Bruno-Faria e Franco (2012) [5]; Emanuelli (2011) [14]; Ferreira e Elia (2013) [15]; Hannum et al. (2008) [16]; Hoic-Bozic et al. (2009) [17]; Jensen e de Almeida (2009) [18]; Jorge et al. (2010) [19] ;Laguardia e Portela (2009) [20]; Lykourentzou et al. (2009) [21];Martins et al. (2012) [22] ; Martins e Gebran (2013) [6]; Marinho et al. (2013) [23]; Mchichi et al. (2011)[24]; Lee and Choi (2011)[25]; Nichols (2010) [26]; Nistor and Neubauer (2010) [27]; Park and Choi (2009) [28]; Patterson and McFadden (2009) [29] ; Pedroso et al. (2013) [30]; Pacheco et al. (2011) [31]; Pacheco et al. (2008) [32]; Pavanelli (2009) [33]; Roblyer e Davis (2008) [34]; Silva et al. (2012) [35]; Tao (2008) [36]; Wilges et al. (2010) [37]; Wingkvist and Ericsson (2012) [38]; Bentes and Kato (2014) [39]; Bittencourt and Mercado (2014) [40]; Braga et al (2014) [41]; Cechinel et al (2015) [42]; Cornelio et al (2015) [43]; Cukusic et al (2014) [44]; Vieira (2015) [45]; Paschoalino et al (2015) [46]; Detoni et al (2014) [47]; Fernandes et al (2014) [48]; Gazza and Hunker (2014) [49], Khali et al (2014) [50]; Lima and Junior (2015) [51]; Lucena et al (2015) [52]; Mauricio (2015) [53]; Deschacht and Goeman (2015) [54]; Oliveira (2014) [55]; Reino et al (2015) [56]; Ribeiro et al (2014) [57]; Rigo et al (2014) [58]; Santos et al (2014) [59]; Schlemmer (2015) [60];

[B] https://rapidminer.com

Silva et al (2015) [61]; Tamariz and Souza (2015) [62]; Yukselturk et al (2014)[63].

Most of the work relies on analyzing the motives for high dropout rates in distance learning. The frequent motives for dropout were mainly concerning the lack of eye-to-eye contact with the teacher and sensation of isolation; workload, deadlines; and personal problems, among others [12] [14] [20] [25] [64] [23] [39] [40] [47] [49] [50] [55] [58] [59] [41] [45] [51] [46] [56] [60]. We synthesize them in Table I, given at the right columns the number of papers where the cause was cited and its associate percentage from the total that somehow address the issue. In addition, it is observed the occurrence of several researches about the identification of why the learners give up the course and means for preventing them to leave the course before its end [21][22][27][28][34][35][37].

TABLE I. REASONS FOR THE DROPOUT.

Causes	#	%
Lack of face-to-face relationship between teacher and learners	31	52
Lack of contact with classmates (sensation of isolation)	26	43
Unsatisfactory tutoring (bad interactions and feedbacks)	26	43
Distance learning model adaptation	23	38
Lack of motivation	20	33
Technological problems (insufficient technical knowledge for using computers)	19	32
Personal problems (health, family, others)	18	30
Lack of time for studying	18	30
Learner’s low satisfaction level	15	25
Generic organization problems of classes (instructional design)	14	23
Lack of studying organization and no fulfillment of tasks deadlines	14	23
Financial problems	12	20
Professional problems or excessive working hours	10	17
Lack interactions with classmates or teacher	9	15
Difficulty in learning (Low effective performance)	9	15
Tasks complexity and cognitive overload level	8	13
Expression hardship on digital environments	7	12
Internet connection difficulties	7	12
Overload of activities during the course	6	10
Lack of administrative support	6	10
Demographic characteristics problems (age, sex, geographical location)	6	10
Lack of interest on contents	3	5
Lack of computer access	3	5
Material delivery problems	1	2
Software and hardware resources incompatibility	1	2
Activities’ excessive ease	1	2
Lack of learner’s tenacity	1	2
Lack of library access	1	2

Considering the top three reported causes, we feel that our claim of working with someone who has complementary skills could motivate learners to produce better should be more explored. Therefore, we define new research questions involving pair collaboration and pair evaluation in distance learning. The new RQs were:

- RQ2: What are the existing approaches to pair formation for collaborative learning in DL? Are the learners' skills and knowledge taken into account? If so, how?
- RQ3: What are the existing approaches for pairs learning evaluation while adopting pairs for collaborative learning in DL? Is individual learning taken into account? If so, how?

The protocol was run again, considering as reference search strings: *("distance education") AND ("pairs training" OR "peer training")* for RQ2 and *("peer evaluation" OR "evaluation by pairs" OR "pairs evaluation")* for RQ3.

The references that somehow addressed RQ2 are Mesquita (2008) [65], Müller and Silveira (2013) [66], Silva et al (2015) [67], Chagas 2014 [68]. For this question the number of relevant results shows that research on the adoption of pair collaboration in the distance learning context is still in its infancy. Müller and Silveira present a report on using pairs in a collaborative system, where pairs are created considering similar profiles. Chagas proposes a system were pair formation is based on the learners' knowledge similarities, while Silva et al. propose the adoption of a model for social combination to identify the pairs. In addition, Mesquita reports the use of pairs consisting of one local and one foreigner student to learn languages, and the sole criterium for pair formation was the students' origin.

The references that somehow addressed RQ3 are Hayashi et al. (2013) [69]; Sirotheau et al. (2011) [70]; Ugulino et al. (2009) [71]; Deus (2012) [72]; Uchôa e Uchôa (2013) [73]; Lee (2009) [74]; Pereira e Figueiredo (2010) [75]; Lai et al. (2011) [76]; Kist e Brodie (2011) [77]; Mellati and Marzieh (2014) [78]; Marsico and Temperini (2014) [79]. Nevertheless, none of them present an approach for pair learning evaluation.

At the end of the protocol second run, from 10 publications included, 04 were considered as relevant for RQ2 and from 25 publications included, 11 were considered as relevant for RQ3.

After the results of the protocol second run we had evidences that the proposition of a model for pair collaboration that is based on complementary cognitive abilities to support teaching and learning through the Web may be a relevant strategy to deal with the top three dropout causes in distance learning courses. In addition, as agile methods are successfully adopted for pair collaboration while developing software, we decided to search for any usage of agile methods to support learning activities. Another question (RQ4) was defined.

- RQ4: Are agile methods adopted for teaching and/or learning issues diverse from software development? If so, what are they and how do they do it?

The new protocol run was initiated considering *(teaching AND learning AND ("agile method" OR "agile methodology" OR "agile strategy" OR "agile approach"))* as reference search string. The single reference that somehow addressed this question is Moraes et al. (2013) [80]. Here, the SCRUM process [81] is adopted to propose means to learners for self-regulated learning. By self-regulated learning they mean self-learning where the learner develop abilities related to autonomy, proactivity, organization and planning to self-regulate its own learning path.

After the third run of the protocol, from 41 documents included, only one was considered relevant. Thus, we had enough evidences that proposing a model based on pair collaboration to support teaching and learning through the web could be an interesting strategy to deal with the top three causes for high dropout rates in web-based courses. In addition, since existing work usually adopts similarities for identifying pairs, we decided for using complementarities for the same purpose. Also, as to evaluate knowledge acquisition one needs to assess the learners' knowledge, we decided to search for discovering what kind of metrics were adopted to do the diagnosis and the formative evaluation in distance learning. The new question (RQ5) was defined.

- RQ5: What are the approaches for measuring the learner's knowledge and skills during formative or diagnosis evaluation in DL?

The new protocol run was initiated considering the reference search string *("distance education") AND ("diagnostic evaluation" OR "diagnostic assessments" OR "formative evaluation" OR "formative assessments")*.

The results of the running consisted of 10 relevant documents, from 50 included. They were: Araujo e Aranha (2013) [82]; Louzada et al. (2011) [83]; Nunes et al. (2013) [84]; Venancio e Lopes (2013) [85]; Lima (2008) [86]; Guan et al. (2013) [87]; Morais et al (2014) [88]; Kamardeen (2014) [89]; Oliveira (2015) [90]; and Baleni (2015) [91].

Venancio and Lopes provide a review of existing work related to how the evaluation is made in interactive learning environments in Brazil and they conclude that the issue is still immature and deserve more research efforts. Araujo and Aranha considered formative evaluation as inherent to digital games. Lima proposes the definition of a Dependency Map to evaluate knowledge and skill and Guan and colleagues propose an adaptive algorithm for providing self-adaptive diagnosis and evaluation. Oliveira and Morais et al discuss about the multidimensional character of knowledge evaluation. Kamardeen advocate that an integrated assessment scheme is essential in an educational setting for driving the student learning. Baleni suggests that the adoption of formative assessment along the learning process could influence the learners' achievement.

III. New Findings and Insights

Considering all the 220 papers analyzed, we found several (94) discussing the reasons of the dropout rate in distance learning courses. Among these 94 papers, few of them were about dropout prediction. In fact, some of them discussed about how to identify learners with some tendency to give up the course [21] [22] [26] [28] [34] [35] [37]. More recently, Educational Data Mining [47] [42] [58] [60] [63] is a trend for analyze large amount of data and finding ways to forecast when and why learners dropout.

Even more rare was the usage of pairs and Agile approaches as a technique to organize and promote the learner educational path in distance learning. Only one paper considered learning in pairs in non-related computing courses. There was no literature using Agile methods to support learning activities in a general context of distance learning.

Nonetheless, there is a work which states that an agile approach is suitable for self-regulated learning [80], which is closely related to the kind of learning students may pursue while engaging in distance learning courses.

Moreover, it is well known that one of the pillars of agile approaches is work in pairs to build software, which had already proved a successful way to foster collaboration during the development process. Therefore, the adoption of pairs to perform learning activities could profit from the use of an agile approach to foster collaboration between the pair.

Having these insights reinforced by the systematic review, we define a model to support learning in pairs in a distance learning context. The steps to define the model are: (i) adapt an agile method to the process of teaching and learning through the web; (ii) define a diagnosis technique to assess students' knowledge and abilities; (iii) considering complementary knowledge, define a strategy for pair formation; and (iv) define criteria for pair assessment. Such a model can be used to support general web-based learning contexts, including MOOCs.

IV. iMPaCTS: A Model for Pair Collaboration Tool Support

The aim of the model presented here is to reduce the learner's sense of isolation in distance learning education, and increase their motivation to follow the course. This model promotes pair formation in a complementary basis considering the knowledge and characteristics of each pair member. Besides, it adopts the agile method Scrum to stimulate collaboration between learners.

It is called iMPaCTS for emphasizing the use of the web as an interactive environment to support learning through pair collaboration. It is composed of 3 modules: (i) pre-learning; (ii) pair learning; and (iii) post-learning. The basis for the model is the learning unit (LU), which represents the fine grained unit that composes a course (or discipline).

The pre-learning module is responsible for evaluating the learner's knowledge level concerning some LU, prior to her/his engagement in the pair learning. Such evaluation could be made through the use of questionnaires. This information will be stored in a proficiency database.

The proficiency database general model is a table with attributes by rows and criteria by columns. This allows a very flexible model, where the teacher can vary the criteria in accordance to the activity or subject under focus. It is also possible to add new criteria (columns), allowing the model evolution. In addition, the proficiency database could be initially populated reusing learner's information from previous courses that were already available in the system. Nevertheless, an ontology could be used to provide interoperability with other systems.

The learning pair is the main module of iMPaCTS. It is responsible for pair formation, fostering collaborative learning and providing the formative evaluation, for each LU of the course. For each LU, learners are grouped in pairs that are defined in accordance to the proficiency database. Currently, pair formation is performed by the system taking into account the LU's prerequisites, selecting the convenient rows in the proficiency table.

The matching is performed taking into account the learners' abilities and knowledge, in such a way the pair would be complementary. For instance, considering two attributes, X and Y, the learners A and B could form a pair if A had a weak score in attribute X and a high score in Y, while B had the opposite. This is the staring point to foster pair collaboration.

During the course evolution, the proficiency database is dynamically updated with information sourced from the formative evaluation after finalizing each LU. For this reason, if a new LU is to be initiated, with the same set of prerequisites, the pair matching could be very different. As a result this module proficiency database is the changes in columns of the proficiency table.

The post-learning module is responsible for evaluating the learner's knowledge level concerning some LU, after to her/his engagement in the pair learning and finalization of the activities proposed in a LU. Such evaluation could be made through summative evaluation, which considers the learner proficiency during pre-learning and her/his evolution along the LU execution. This information will update the proficiency's database by revising the attributes of the proficiency table, i.e., changing its rows. For instance, the analysis could suggest new attributes or the replacement of one coarse-grained attribute by fine-grained ones. A general view of the model is presented in Fig. 3.

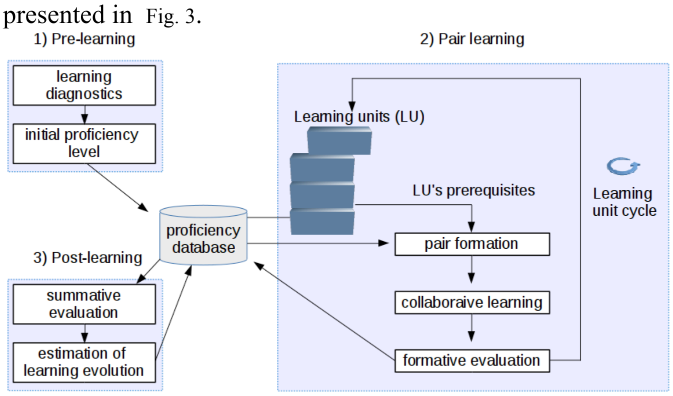

Fig. 3 iMPaCTS general view

A. The Pair Learning Module

Considering the role of the Pair Learning Module in iMPaTCS, a description of how it is organized and implemented is given using a component-based approach. This should enable the introduction of several criteria for pair formation, which is a sensitive aspect of the model.

Therefore, a kernel for pair formation should be defined and the introduction of new strategies or criteria for pair formation could be made by simply plug in a component containing their implementation to its kernel. Nevertheless, the same is valid for strategies for fostering pair collaboration or providing the formative evaluation.

For validating the model we described only one criterium for pair formation, as well as for fostering pair collaboration and providing formative evaluation.

A. Pair formation criteria

The first implementation of pair formation adopts the Pearson correlation coefficient [92] as the criteria for choosing the members of a pair. This coefficient is a statistical metric for analyzing the linear correlation (dependence) between two random variables, with the variation range [-1,1]. The close to 1 (or to -1) the coefficient is, the more dependent variables are. Positive correlation means that both variables increase (or decrease) together and negative correlation means that the variables present opposite behavior. On the contrary, the close to 0 the correlation is, the more independent the variables are. Thus, as we are interested in complementary knowledge and skills for composing the pair, the idea is to associate with each learner a table of proficiency by subject (or LU). This table contains proficiency values that will be used to find other learner that presents negative correlation with them.

B. Pair collaboration

In order to foster collaboration between pairs, we have adapted the agile method Scrum, which resulted in the *Scrum Method for Learning* (*SML*). The SML has an iterative and incremental life cycle, as the original Scrum method [93]. For life cycle we mean the time during which a LU is executed.

The roles "product owner", "Scrum master" and "team" used in Scrum methods are played in SML by the teacher, some system features and learners, respectively. Therefore, as "product owners", teachers are responsible for (i) determining the course pre-requisites; (ii) defining the course's LU and its associate release date; (iii) taking part during interaction meetings; (iv) keeping the learners working.

In Scrum, the "scrum master" is responsible for (i) allowing the collaboration between all players; (ii) removing impediments and avoiding distraction in the team; (iii) ensuring that the team will follow the agile rules, including the daily meetings (*stand-ups*), and others meetings (planning, demos, revision, and retrospective); (iv) facilitating the team meetings and the decision meetings. In our case, system features will fulfill such responsibilities by (i) providing an area for collaborative work; (ii) an area for meeting sessions; (iii) providing warnings with some helping recommendation; and (iv) reporting the learner's performance.

In the traditional Scrum, the team is responsible for turning the list of requirements in delivered products. In SML, the role "team" is played by pairs of learners. Eventually, one team will have three learners. The team will organize themselves and their learning process.

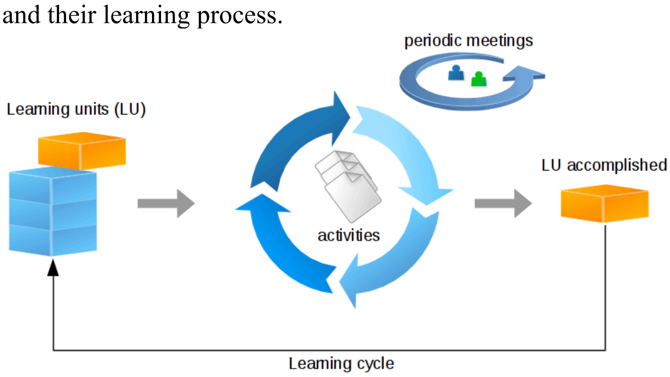

Fig. 4 SML: an adaptation of SCRUM to the learning process

The SML process describes an iterative learning cycle where a course is composed of several LU and each of them is processed during one SML cycle. The matching with SCRUM is that an LU in SML is a *sprint* in SCRUM. Therefore, teachers fix the time for the LU to be completed and, at the beginning, planning meetings take place involving teacher and pairs of learners to establish the learning objectives.

The pairs start working on the LU activities and attend periodic meetings that may involve other pairs or the teacher. After completing all the LU activities, the cycle is completed with the evaluation of the results obtained by each pair. A general view of the process is presented in Fig 4.

C. *Pair evaluation*

During the learning cycle of SML, several activities are conducted individually, but with pair collaboration. The formative evaluation of each learner is dynamically built during the cycle and it is finalized for each LU. Such evaluation will be used to update the learners' proficiency on LU.

V. Conclusion and Future work

In this paper we described an iterative systematic review of the literature that was conducted to confirm that the proposition of a model for pair collaboration to support web-based teaching and learning activities could be an interesting strategy to deal with high dropout rates of web-based courses. In addition, we presented iMPaCTS, a model for pair collaboration in distance learning environments. The underlying idea of providing pair collaboration is increasing motivation and decreasing dropout among learners that are engaged in distance learning courses. We believe that this modality of learning will continue growing considering the number of delivered courses and engaged learners.

Prior the model definition, we define some research questions to guide the review and the results shows that several researches are concerned about the high dropout rate in distance learning and some solutions for preventing it are been addressed, but most of them are related on the identification of candidates to dropout instead of trying to motivate them from the beginning of engagement in a course. In addition, although the adoption of an agile approach was pointed as suitable for self-regulated learning, no work on using such approaches to support distance learning activities were found. Increase motivation and production by working in pairs is a reality in software development that uses agile approaches and the review showed that the adoption of the same idea for promoting learning could be interesting.

iMPaCTS is composed of three modules, pre-learning, pair learning and pos-learning, and a proficiency database. By defining the pre and pos-learning modules we created means for populating and updating the proficiency database, which is used to establish criteria for pair formation considering, for instance, complementary abilities related to a learning unit.

The model allows flexibility to define strategies for pair formation, as well as the way collaboration would be fostered between pairs and the way formative evaluation will be built.

The model validation is out of the scope of this paper and will be subject of consideration further. Currently we start defining a series of experiments to analyze the model efficacy on increasing motivation and decreasing dropout in distance learning courses. For that, we are implementing iMPaCTS as described here as a Moodle module. Having such an implementation will allow us to run experiments with small, medium and large scale web-based learning contexts. After finalizing the experiments we intend to implement new strategies for pair formation and formative evaluation.

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