A Catalog of Pedagogical Patterns for Learning Applications

Maria Lydia Fioravanti
Institute of Mathematics and Computer Science
University of São Paulo, São Carlos/SP, Brazil
mlfioravanti@usp.br

Ellen Francine Barbosa
Institute of Mathematics and Computer Science
University of São Paulo, São Carlos/SP, Brazil
francine@icmc.usp.br

***Abstract*—This Research Full Paper presents a catalog of pedagogical patterns for learning applications. Patterns and pattern languages are mechanisms to describe best practices and good designs to capture experience in a way that it is possible for others to reuse such experience. Similarly, pedagogical patterns try to capture expert knowledge on the practice of teaching and learning. Actually, issues related to teaching and learning have been increasingly discussed and studied lately, particularly regarding the development and delivery of computational learning applications. In this scenario, the existing learning applications, despite having several benefits and facilities, present problems and challenges that still need to be better investigated. Therefore, pedagogical patterns can be a tool to assist in the design of new teaching and learning applications as well as to the improvement of the existing ones. Motivated by this scenario, we present a catalog of pedagogical patterns established from the results of a systematic mapping conducted in this domain. Such catalog encompasses the patterns available in the literature and can be used as input for the design of learning applications. This study aimed at the identification of studies showing the use of pedagogical patterns as well as the problems solved when using these patterns. The results were extracted from 51 scientific studies, presenting 312 different pedagogical patterns; the set of retrieved patterns provided input to the creation of a pedagogical pattern language.**

I. Introduction

The term "pattern" has the meaning initially given by Christopher Alexander for architectural patterns [1]: *"each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way you can use this solution a million times over, without ever doing it the same way twice"*. That is, a pattern is an abstract solution to a problem in a context.

Similarly, pedagogical patterns try to capture expert knowledge regarding the practice of teaching and learning [2]. The intent is to capture the essence of the practice in a compact form that can be easily communicated to those who need this knowledge. Presenting this information in a coherent and accessible form can mean the difference between the need of every new instructor to relearn what is already well known by senior faculty, as well as the easy knowledge transfer of teaching within the community.

Recently, issues related to teaching and learning have been increasingly discussed and studied by the scientific community. In particular, computational learning applications have shown increasing importance, playing a key role in teaching and training activities [3]. These learning applications are relevant both in academia and in industry.

In this scenario, existing learning applications, despite the benefits and facilities provided, present problems and issues that need to be addressed [4]. These problems and challenges are not only limited to developmental aspects or technologies, but they also include pedagogical aspects. Therefore, pedagogical patterns can be a tool to assist in the design of new teaching and learning applications as well as to the improvement of the existing ones.

Moreover, to the best of our knowledge, there is no complete and well-defined catalog of pedagogical patterns to help on the design and development of learning applications and our work intends to be a step forward in this direction. Thus, this work aims at the identification of studies discussing the use of existing pedagogical patterns and the problems solved by them. To achieve our goal, a systematic mapping was conducted in which scientific studies were analyzed. Based on the results obtained in the systematic mapping, we established a catalog of pedagogical patterns. Such catalog encompasses the patterns available in the literature and can be used as input for the design of learning applications. The results can relevant to outline the current state-of-the-art and also as input to educators.

The remainder of the paper is organized as follows: Section II briefly introduces the related work; Section III describes the systematic mapping conducted in the context of pedagogical patterns; Section IV summarizes the patterns retrieved in the format of a catalog of pedagogical patterns; finally, Section V provides the conclusions and perspectives for future work.

II. Related Work

To the best of our knowledge, there was no complete and well-defined catalog of pedagogical patterns and our work intended to be a step forward in this direction. The main contribution of our catalog is the gathering of this type of pattern and its associated problem solved, which can be used as a guide for users and designers of learning systems.

In this context, we point out two important studies from Bergin et al. [2] and Köppe [5]. The first is the result of the efforts of several authors to build a pattern language based on their own work that was publisehd as a book[2]. Some

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patterns from the *Pedagogical Patterns Project*[1] were revised and rewritten in Alexandrian form [6]. The currently available patterns of this pattern language focus on classroom situations at beginners to advanced level, but their usability is not limited to that, since this pattern language is constantly under construction. The second is more similar to our work, since it is an inventory and categorization of existing lecture-relevant patterns. Despite the similarity of the idea of both above-mentioned works, the inventory formats are different from the one we have adopted, which is more concise. Furthermore, our work is not limited to lectures and aims to present pedagogical patterns from several different works available in the literature.

III. Systematic Mapping

Considering the educational setting, patterns have been explored mainly in the context of electronic learning [7] and used for mobile learning, but such patterns are mainly concerned with developmental and architectural aspects, not addressing the pedagogical issues that could be handled with the use of pedagogical patterns. Therefore, the idea of the conducted systematic mapping was to retrieve the existing pedagogical patterns and analyze those that could be used in the mobile learning context. It is worth mentioning that the systematic mapping presented in this paper is an extension of a previously conducted systematic mapping [8]. The authors identified a need of extending such systematic mapping to update its automated search concerning more recent dates and also to include manual search in specific venues of patterns and pattern languages.

In short, systematic mapping is a type of secondary study that provides a process for a broader review of primary studies and aims to obtain a broad overview of the research area from the relevant primary studies discovered. It identifies the evidence available, as well as the gaps in primary studies and the areas where more primary studies must be conducted [9].

Our systematic mapping followed the guidelines proposed by Petersen et al. [10], which establish the steps shown in Figure 1. The mapping was fully performed by one researcher.

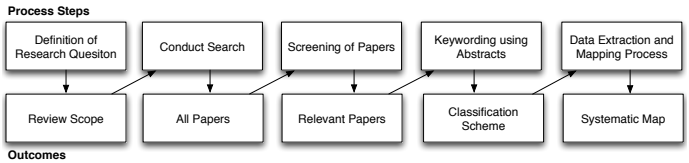

Fig. 1: The Systematic Mapping Process (Extracted from Petersen et al. [10])

A. Definition of Research Questions

The systematic mapping conducted aimed at the identification and analysis of studies on full pedagogical patterns and pattern languages.

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

Aiming to achieve the established goals, a protocol was defined to guide the mapping, in which the following research questions were defined:

RQ1: What pedagogical patterns have been used?

RQ2: What problem or challenge do such pedagogical patterns aim to solve or mitigate?

As shown in Figure 2, the research questions are the outcomes of this step.

B. Search for Primary Studies

The primary studies were identified by search strings in scientific databases or a manual browse through relevant conference proceedings or journal publications. We additionally used the PICOC criteria proposed by Petticrew and Roberts [11] to frame the research questions, since it is a good way of creating search strings to structure them regarding *Population*, *Intervention*, *Comparison*, *Outcome* and *Context* [10].

- **Population:** Research related to pedagogical patterns;
- **Intervention:** Problems and challenges solved or diminished with the use of patterns;
- **Comparison:** Not applicable;
- **Outcome:** Overview of studies that discuss pedagogical patterns or pattern language; and
- **Context:** Industry and Academia.

For our systematic mapping, the string was defined also through the attachment of terms of higher relevance to the research, namely *pedagogical pattern(s)*, *educational pattern(s)*, *learning pattern(s)* and *teaching pattern(s)*. The search terms and their synonyms were defined according to experts' opinions, to the literature and to the set of research questions. The generic search string defined is shown in Table I.

TABLE I: Search string

("pedagogical pattern" OR "pedagogical patterns" OR "learning pattern" OR "learning patterns" OR "teaching pattern" OR "teaching patterns" OR "educational pattern" OR "educational patterns")

Searches were performed in the following databases[2][12], [13]: ACM Digital Library[3], EI Compendex[4], IEEE Xplore Digital Library[5], ISI Web of Science[6], Science@Direct[7], Scopus[8] and Springer Link[9]. The generic search string was adapted to each database selected in accordance with its specificities, which resulted in 6650 studies retrieved. A manual search was also performed in important venues in the context

[2]The searches were conducted on January 26th, 2016 and updated on May 8th, 2017.

[3]http://portal.acm.org

[4]http://www.engineeringvillage.com

[5]http://ieeexplore.ieee.org

[6]http://www.isiknowledge.com

[7]http://www.sciencedirect.com

[8]http://www.scopus.com

[9]http://link.springer.com

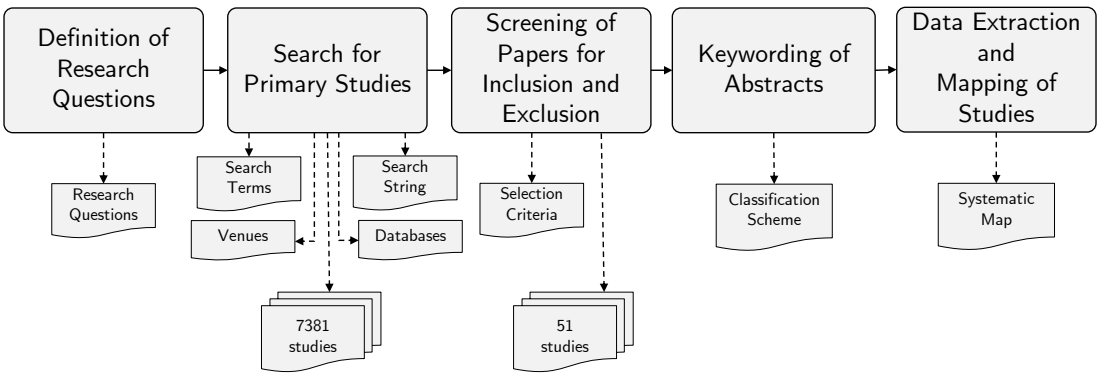

Fig. 2: Systematic Mapping Steps

of patterns such as: PLoP, EuroPLoP[10], online repositories and so forth, and other 731 studies were included. Regarding the first version of this systematic mapping [8], the total number of primary studies retrieved went from 5944 to 7381, with 706 studies being added by automated search and 731 by manual search during the update. The number of studies found in each database is shown in Table II.

TABLE II: Studies found per research database

Research database	Rationale for inclusion	Total of studies
ACM Digital Library	[12]	145 (1.96%)
EI Compendex	[12]	938 (12.71%)
IEEE Digital Library	[12]	378 (5.12%)
ISI Web of Science	[13]	860 (11.65%)
Science@Direct	[12]	164 (2.22%)
Scopus	[13]	1373 (18.60%)
Springer Link	[12]	2792 (37.83%)
Manual Search	-	731 (9.90%))
Total		*7381 (100%)*

C. Screening of Papers for Inclusion and Exclusion

In this step, the supporting criteria for the screening of papers during the mapping execution were defined. Such a definition aimed at the selection, among the works retrieved from the automatic search, of those that could potentially answer the research questions and were directly related to the subject studied. The results were not filtered by year to assure no important study would be missing. Table III shows the inclusion and exclusion criteria.

After the removal of duplicate studies and application of the inclusion and exclusion criteria, 51 studies were selected for the next step. Regarding the first version of this systematic mapping [8], the final number of select studies went from 35 to 51. We can notice that a high percentage of studies was remove and it occurred due to some terms being used in other research areas. Details of this significant reduction in the number of selected papers will be further discussed in the threats to validity (Section III-G).

[10]The software patterns community recommends that all pattern languages be submitted to a writers' workshop in Pattern Languages of Programs (PLoP) conferences, such as PLoP, EuroPLoP, AsianPLoP, and so forth., to improve the patterns. In short, the papers are submitted to two different types of feedback: Shepherding and Writers' Workshop. The shepherding process is essentially a reviewing process involving shepherds and sheeps, in which shepherds are individuals, with experience in pattern writing, assigned to an author's (sheep's) paper with the expressed interest in helping the author improve the pattern. During the conference, the authors attend the writers' workshop in which the paper remain under discussion and the authors get a lot of feedback and suggestions from fellow authors and others about how they can improve their work.

TABLE III: Inclusion and Exclusion Criteria

Type	Criterion
Inclusion	**I1.** Primary studies that have at least one full pedagogical pattern.
Exclusion	**E1.** Primary studies that do not involve the issue of research questions. **E2.** Primary studies that are not available for downloading in the databases selected. **E3.** Primary studies written neither in English, nor in Portuguese. **E4.** Duplicated studies. **E5.** Cover files and proceedings index.

D. Keywording of Abstracts

In this step, we read the abstracts and searched for keywords and concepts that reflected the main contribution of the paper. The context of the research was also identified, which helped the reviewer to define the data to be extracted in the next step.

Our classification scheme considered two main facets. The research facet reflects the research approach used in the papers. We chose the classification of research approaches proposed by Wieringa et al. [14], which proposes the following types of research: Validation Research, Evaluation Research, Solution Proposal, Philosophical Papers, Opinion Papers, Experience Papers. The category facet structured the patterns according to their specific applications was based on ReqML-Catalog, a requirements catalog proposed by Soad et al. [15], once it summarizes important aspects to be contained in a learning application based on the existing systems and expert's knowledge. We considered specifically the pedagogical category of the catalog.

E. Data Extraction and Mapping of Studies

To summarize the results, extract data from the primary studies and answer the research questions, we developed the template shown in Table IV. The main results and the answers to the questions are presented next.

TABLE IV: Data Extraction Form

Data Item	Value	RQ
Study ID	Letter 'S' followed by an integer	
Article Title	Title of the article	
Author(s) Name	Names of the authors	
Year of Publication	Calendar year	
Pattern ID	Letter 'P' followed by an integer	
Pattern	Name of the pattern	RQ1
Problem	Problem solved or diminished by the pattern	RQ2
Research Type	Classification of the research according to Wieringa et al. [14]	
Category	Pedagogical application of the pattern according to Soad et al. [15]	

F. Systematic Mapping Results

In this section, we present an overview of the primary studies found, the patterns extracted, the problem solved and also the category the pattern belonged to and also a discussion of the main results extracted from the 51 studies, towards answering the research questions.

We present the 51 selected studies and their information in Table V. Table VI shows the way the selected studies were categorized regarding research type. We can notice that 94.12% of the studies are *Solution Proposal* and the remainder are *Experience Paper* and *Opinion Paper*. No *Validation Research*, *Evaluation Research* or *Philosophical Papers* were found, which means although authors propose several patterns, they lack validation and evaluation.

Table VII shows the way the 312 patterns extracted from the studies were categorized regarding pedagogical application. Categories as *Educational activities* (15.71%), *Teaching and learning processes* (13.46%), *Feedback* (10.26%), *Collaboration* (9.94%), *Engagement* (8.01%) and *Motivation* (7.69%) are highlighted, since they reflect the reality of the major difficulties in teaching environments relate to both teacher and learner. Regarding the previous version of this systematic mapping, it was possible to identify only 109 pedagogical patterns.

Figure 3 shows a bubble chart with the distribution of 312 patterns extracted from 51 studies, based on *Research type* (Y axis), related to *Category* (X axis). The size of the bubble represents the number of studies, shown inside the bubble.

The distribution of studies among research types suggests a gap concerning the use, validation and evaluation of pedagogical patterns. A higher concentration is observed in the solution proposals, as already discussed, which suggests a lack of investigations on the validation of the use of pedagogical patterns. Figure 3 also shows a variation in the distribution of studies among the various categories. For example, *Educational activities*, *Teaching and learning processes*, *Feedback*, *Collaboration*, *Engagement* and *Motivation* show a higher concentration of studies (i.e., approx. 57% of the papers tackle such categories) which may suggest such categories represent the main challenges in the educational setting.

G. Threats to Validity

Although systematic mappings are more accurate than other approaches, there are some threats to their validity. Regarding *studies identification*, the main threat is that the automatic search may not have collected all relevant primary studies, i.e., the search string was not as inclusive as necessary or the digital libraries considered did not include all relevant venues. To mitigate this risk, a twofold approach was adopted: (i) a manual search was included in the proceedings of the main publishers in the topic; and (ii) a wide search string was defned, so that the search results were as inclusive as possible, although many papers had been returned.

However, this approach caused a side effect. The *low rate of selected studies*: only 0.69% of the studies extracted from the database had meaningful information, because the terms used to define our search string are also terms used in several other areas. For instance, *learning patterns* can also refer to an Artificial Intelligence technique, more specifically in the machine learning domain, or to cognitive styles that are "the characteristic behaviours of learners that serve as relatively stable indicators of how they perceive, interact with, and respond to the learning environment" [66].

Finally, to mitigate *reproducibility* threats, the steps of our study were clearly stated in our protocol and can be reproduced by other researchers. However, we understand the reproduction of the systematic mapping by other researchers may lead to slightly different sets of primary studies due to biases, e.g., the application of the inclusion and exclusion criteria, or even databases updates may lead to a different set of primary studies to be analyzed. This threat was mitigated to some extent through a comprehensive documentation of challenges faced and decisions made upon them. Despite some potential minor differences, we believe the results and observations would be predominantly similar in replication studies.

IV. The Catalog

Based on the results obtained in the systematic mapping, a catalog was created listing patterns as well as the problem that they solve. The catalog comprises 312 pedagogical patterns that can be used in several educational scenarios. The catalog contains four fields:

Pattern ID: A unique identifier for the pattern;
Study ID: Identifier of the study(ies) that present the pattern;
Pattern Name: Name of the pattern;
Problem: Problem solved or diminished by the pattern.

The contribution of such catalog is twofold: (i) the catalog contains all the patterns available in the literature, facilitating their recovery and subsequent use; and (ii) the catalog can be used as input for the design of learning applications.

TABLE V: Selected studies

ID	Title	Author(s) Name	Year	Reference
S01	Patterns in teaching software development	Angster et al.	2003	[16]
S02	The Potential of Christopher Alexander's Theory and Practice of Wholeness: Clues for Developing an Educational Taxonomy	Bauer and Baumgartner	2010	[17]
S03	Applying and developing patterns in teaching	Bennedsen and Eriksen	2003	[18]
S04	The Reinforcement Pedagogical Pattern for Industrial Training	Berenbach and Konrad	2008	[19]
S05	Active Learning and Feedback Patterns: Version 4	Bergin	2006	[20]
S06	The "Instructed-teacher": A Computer Science Online Learning Pedagogical Pattern	Bower	2008	[21]
S07	Interaction design patterns for classroom environments	Breuer et al.	2007	[22]
S08	Patterns as a paradigm for theory in community-based learning	Carroll and Farooq	2007	[23]
S09	A hybrid system of pedagogical pattern recommendations based on singular value decomposition and variable data attributes	Cobos et al.	2013	[24]
S10	Cog-Learn: An e-Learning Pattern Language for Web-based Learning Design	Anacleto et al.	2009	[25]
S11	A Pedagogical Pattern for Bringing Service into the Curriculum via the Web	Erickson and Leidig	1997	[26]
S12	Creative Education Patterns: Designing for Learning by Creating	Harashima et al.	2014	[27]
S13	Learning Patterns: A Pattern Language for Creative Learning II	Iba and Miyake	2010	[28]
S14	Pedagogical Patterns for Creative Learning	Iba et al.	2011	[29]
S15	Learning Patterns III: A Pattern Language for Creative Learning	Iba and Sakamoto	2011	[30]
S16	P2N: A Pedagogical Pattern for Teaching Computer Programming to Non-CS Majors	Jiang et al.	2011	[31]
S17	Developing a Pedagogical Infrastructure for Teaching Globally Distributed Software Development	Keenan and Steele	2011	[32]
S18	Continuous Activity: A Pedagogical Pattern for Active Learning	Köppe	2011	[33]
S19	A Pattern Language for Teaching Design Patterns (Part 1)	Köppe	2011	[34]
S20	A Pattern Language for Teaching Design Patterns (Part 2)	Köppe	2011	[35]
S21	A Pattern Language for Teaching in a Foreign Language: Part 1	Köppe and Nijsten	2012	[36]
S22	A Pattern Language for Teaching Design Patterns	Köppe	2013	[37]
S23	Improving Students' Learning in Software Engineering Education Through Multi-level Assignments	Köppe and Pruijt	2014	[38]
S24	Lecture Design Patterns: Improving the Beginning of a Lecture	Köppe and Portier	2014	[39]
S25	Lecture Design Patterns: Laying the Foundation	Köppe and Schalken-Pinkster	2015	[40]
S26	Continuous Feedback Pedagogical Patterns	Larson et al.	2008	[41]
S27	Patterns on Civic Engagement, Service Learning and Campus Community Partnerships from the "Program for the Advancement of Service Learning and Social Responsibility of Universities"	Miller et al.	2015	[42]
S28	Guess my X and other techno-pedagogical patterns: toward a language of patterns for teaching and learning mathematics	Mor	2010	[43]
S29	What learners teach us: e-learning patterns for adult ICT education	Rogier et al.	2013	[44]
S30	Pattern for Graduate Student Company	Ruskov et al.	2010	[45]
S31	Patterns for Teaching Software in Classroom	Schmolitzky	2007	[46]
S32	Learner-centered software engineering education: From resources to skills and pedagogical patterns	Seffah and Grogono	2002	[47]
S33	Pedagogical patterns—successes in teaching object technology: a workshop from OOPSLA'96	Sharp et al.	1996	[48]
S34	Blended learning patterns for course design	Smith et al.	2010	[49]
S35	Patterns for gaining different perspectives	Bergin et al.	2001	[50]
S36	Patterns for active learning	Eckstein et al.	2002	[51]
S37	Learning Patterns for Self-directed Learning with Notebooks	Harashima et al.	2014	[52]
S38	Lecture Design Patterns: Improving Interactivity	Köppe and Schalken-Pinkster	2013	[53]
S39	Patterns for Creative Thinking	Kohls	2012	[54]
S40	Flipped classroom patterns - Controlling the pace	Köppe et al.	2016	[55]
S41	Learning Patterns for Group Assignments: Part 2	Cortie et al.	2013	[56]
S42	Towards a pattern language for learning management systems	Avgeriou et al.	2003	[57]
S43	Educational Design and Networked Learning: Patterns, Pattern Languages and Design Practice	Goodyear	2005	[58]
S44	Fourteen Pedagogical Patterns	Bergin	2000	[59]
S45	Educational Patterns for Generative Participants: Designing for Creative Learning	Shibuya et al.	2013	[60]
S46	Patterns for the Creation of Elearning Content and Activities in a University Setting	Holden et al.	2010	[61]
S47	Learning Patterns for Group Assignments: Part 1	Köppe	2012	[62]
S48	A Pattern Language for Teaching in a Foreign Language: Part 2	Köppe and Nijsten	2012	[63]
S49	Pedagogical Patterns: Advice For Educators	Bergin et al.	2012	[2]
S50	Learning Patterns: A Pattern Language for Creative Learning	Iba et al.	2014	[64]
S51	E-learning Design Patterns Repository	E-LEN Project	2004	[65]

An illustrative excerpt from the catalog can be found in Table VIII. For readability reasons, the full version of the catalog is available at `https://goo.gl/c6ovVB`.

Regarding the use of the catalog as input for designing learning applications, we can highlight that patterns P004, P006, P018, P024, P057, P058, P060, P065, P099, P100, P209, P238, P258 and P282, for instance, were considered to compose a pedagogical pattern language entitled MLearning-PL. MLearning-PL[11] [67] is a pedagogical pattern language whose main idea is to provide support on pedagogical issues to

[11] `https://goo.gl/J22wdC`

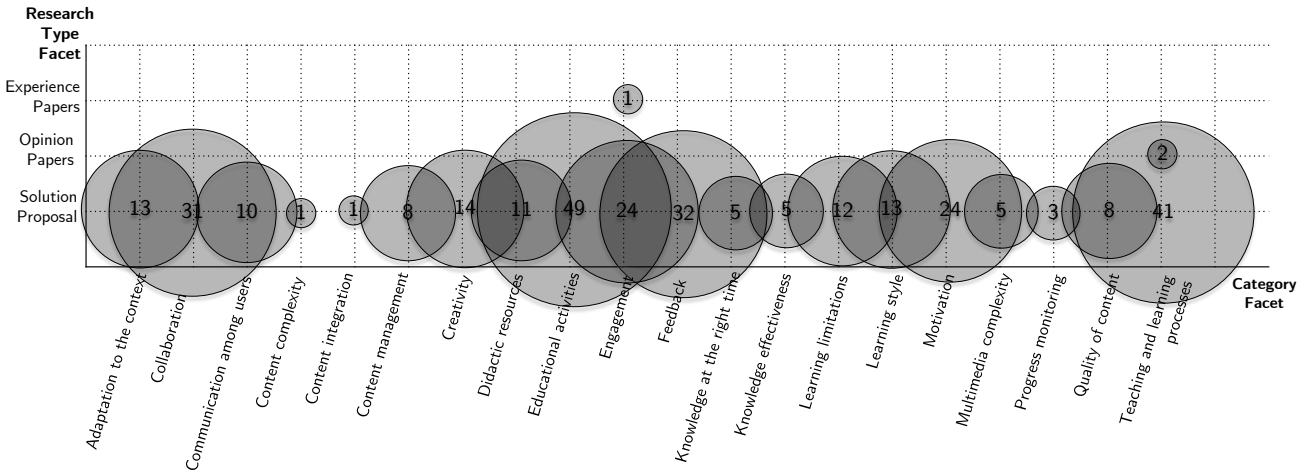

Fig. 3: Systematic Map

TABLE VI: Research Type Distribution

Research type	Number	Studies
Experience Papers	1	S33
Opinion Papers	2	S01, S03
Solution Proposal	48	S02, S04, S05, S06, S07, S08, S09, S10, S11, S12, S13, S14, S15, S16, S17, S18, S19, S20, S21, S22, S23, S24, S25, S26, S27, S28, S29, S30, S31, S32, S34, S35, S36, S37, S38, S39, S40, S41, S42, S43, S44, S45, S46, S47, S48, S49, S50, S51

help analysts to avoid or diminish already known pedagogical problems. Several patterns from the catalog were used as a basis to write the patterns of MLearning-PL. The idea was to understand the the context, problem and solution and analyze wheter it fitted or not the mobile learning context. MLearning-PL was already evaluated by means of experimental studies which showed preliminary empirical evidence of the applicability, effectiveness and efficiency of its adoption. MLearning-PL was also validated by patterns experts and a validation with education experts is being planned and will be conducted shortly.

V. Conclusions and Future Work

In this paper, we presented a catalog of pedagogical patterns to be considered in the design of learning applications. The pedagogical patterns approach has been motivated by the need of exchanging knowledge and good practices between research literature and the real world. The goal is to support practitioners and also provide means of communication among stakeholders (e.g., teachers and education or technology researchers).

The methodology used was a systematic mapping, conducted through well-defined steps to provide greater theoretical and scientific reliability. The aim was to perform a fair assessment (not biased) for the research topic by an auditable, reliable and accurate approach.

As mentioned, the catalog was already applied as it served as input for the creation of a pedagogical pattern language for the mobile learning domain, entitled MLearning-PL. MLearning-PL was already evaluated and the results showed preliminary empirical evidence of the applicability, effectiveness and efficiency of its adoption.

As future work, we point out the the need to keep the catalog up-to-date so that users can continue to benefit from its use. We can also mention the use of patterns from the catalog in other educational scenarios such as Active Learning, MOOCs, Flipped Classroom, and so forth.

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TABLE VII: Distribution of Patterns into Categories

Category	Number	Patterns
Adaptation to the context	13	P35, P36, P37, P45, P52, P128, P204, P205, P302, P303, P304, P305, P306
Collaboration	31	P10, P11, P33, P51, P62, P63, P64, P73, P87, P92, P95, P97, P104, P117, P126, P141, P145, P161, P164, P190, P192, P217, P239, P240, P242, P245, P247, P271, P279, P285, P312
Communication among users	10	P69, P113, P123, P137, P170, P176, P181, P211, P277, P301
Content complexity	1	P154
Content integration	1	P39
Content management	8	P46, P67, P98, P122, P165, P261, P265, P307
Creativity	14	P13, P15, P19, P27, P47, P48, P114, P149, P171, P180, P193, P223, P252, P287
Didactic resources	11	P07, P25, P30, P103, P105, P143, P175, P196, P250, P256, P272
Educational activities	49	P08, P20, P26, P32, P49, P50, P65, P85, P86, P90, P93, P94, P107, P121, P129, P140, P163, P172, P177, P178, P183, P184, P186, P194, P199, P203, P216, P219, P222, P224, P225, P229, P231, P241, P244, P257, P259, P260, P263, P280, P281, P288, P292, P295, P298, P299, P308, P309, P310
Engagement	25	P06, P24, P29, P31, P60, P78, P89, P100, P110, P127, P146, P210, P230, P233, P248, P249, P266, P268, P270, P278, P284, P286, P291, P300, P311
Feedback	32	P05, P09, P53, P55, P59, P66, P71, P80, P81, P82, P83, P84, P101, P111, P116, P120, P131, P132, P173, P174, P187, P195, P201, P202, P207, P226, P243, P253, P267, P276, P290, P294
Knowledge at the right time	5	P03, P40, P42, P76, P106
Knowledge effectiveness	5	P38, P134, P212, P235, P258
Learning limitations	12	P43, P75, P88, P109, P138, P169, P189, P198, P214, P234, P273, P293
Learning style	13	P18, P57, P58, P77, P91, P139, P155, P158, P182, P206, P228, P238, P283
Motivation	24	P04, P14, P17, P23, P72, P74, P99, P102, P130, P142, P144, P156, P159, P162, P168, P200, P209, P218, P220, P221, P237, P251, P254, P282
Multimedia complexity	5	P41, P112, P166, P179, P227
Progress monitoring	3	P136, P213, P269
Quality of content	8	P16, P61, P124, P274, P28, P96, P188, P264
Teaching and learning processes	42	P01, P02, P12, P21, P22, P34, P44, P54, P56, P68, P70, P79, P108, P115, P118, P119, P125, P133, P135, P147, P148, P150, P151, P152, P153, P157, P160, P167, P185, P191, P197, P208, P215, P232, P236, P246, P255, P262, P275, P289, P296, P297

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TABLE VIII: Excerpt of the Catalog of Pedagogical Patterns

Pattern ID	Study ID	Pattern Name	Problem
P001	S51	(Learning) Routines	How can the development of Learning Routines be supported?
...	...	...	...
P004	S13, S50	Acceleration to Next	It frequently happens that people slack off their efforts subconsciously just before the goal
...	...	...	...
P006	S36, S49	Active Student	The deep consequences of a theory are unlikely to be obvious to one who reads about, or hears about the theory. The unexpected difficulties inherent in using the theory or applying the ideas are not likely to be apparent until you actually do use the theory.
...	...	...	...
P018	S13, S50	Brain Switch	Thinking tends to be leaning to only logic or intuition, which each is not enough to achieve a breakthrough
...	...	...	...
P024	S50	Chain of Excitement	It is not easy to actively continue exploring and studying.
...	...	...	...
P057	S35, S49	Different Approaches	Communication always takes place between a sender and a receiver, and the effectiveness of communication isn't measured by what the sender says, but by what the receiver understands. Every person obtains information differently, using different sensory modalities. Some people, the visuals, learn most effective by watching; the auditories, by listening; and the kinesthetics, through action. Be aware: Not every student uses the same sensory modality as you!
P058	S36, S49	Different Exercise Levels	The most important aspect of exercises is to allow the participants to improve their newly acquired skills by working on a topic on their own. If everyone is given the same exercise, then some participants will find it overly simple, and do not learn anything, while others consider the exercise too difficult, are frustrated because they can't do it, and do not learn anything. To improve his skills, the exercise must be located at the upper limit of the participant's current skill level, but this will be different for each participant.
...	...	...	...
P060	S49	Digestible Packets	People can only concentrate for a limited period of time. This is the primary reason to include regular Breaks. If a topic takes longer than the time people can concentrate, the participants will have difficulties understanding the topic in its entirety. Because comprehension decreases, the motivation will decrease, too, and the seminar will be considered difficult.
...	...	...	...
P065	S44, S49	Early Bird	How can you get the students working on larger artifacts without overwhelming them?
...	...	...	...
P099	S44, S49	Gold Star	Normally the reward structure is private. In grading you give the student praise, but this loses the opportunity to show other students what you value most highly.
P100	S50	Good Rivals	It is difficult to maintain efforts alone.
...	...	...	...
P209	S50	Playful Learning	Learning as a duty is ineffective and painful.
...	...	...	...
P238	S35, S49	Role Play	The complexity of some concepts makes them hard to understand with only abstract explanations. Furthermore, difficulties in understanding complex concepts may frustrate the students. You not only would like to provide a positive learning environment, so even learning complex topics might be fun, but you also want to take into account that different people learn things best using different sensory modalities. Most teaching styles respect the auditories, a few the visuals, and even fewer the kinesthetics.
...	...	...	...
P258	S09, S35, S44, S49	Spiral	Topics in a course are often interrelated and many different topics are required for students to have enough tools with which to solve interesting problems
...	...	...	...
P282	S15, S50	Tangible Piles / Tangible Growth	It is not easy to keep yourself motivated to learn
...	...	...	...
P312	S46	Writing on the Wall	How to share ideas and resources and engage with the wider community when materials are in the early stages of design allowing others to contribute to the shaping of the learning?

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