A Systematic Mapping on Pedagogical Patterns

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***Abstract*—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 this experience. Similarly, pedagogical patterns try to capture expert knowledge regarding the practice of teaching and learning. Issues related to teaching and learning have been increasingly discussed and studied, particularly computational learning applications. In this scenario, the existing educational applications, despite having several benefits and facilities, present problems and challenges that 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. This study aims at the identification of studies showing the use of pedagogical patterns as well as the problems solved when using these patterns. To do so, we have conducted a systematic mapping in which 35 scientific studies presenting 109 pedagogical patterns were analyzed. The results are relevant to outline the current landscape of the area and they also highlight discussions that may guide future investigations on the topic.**

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"*. In other terms, 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, the existing educational applications, despite having several benefits and facilities, present problems and challenges that need to be better investigated [4]. These problems and challenges are not limited to technical aspects, 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.

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 articles from seven different sources were analyzed. The results are relevant to outline the current landscape of the area, also highlighting discussions that may guide future investigations on the topic. More specifically, the results can provide a guide for proposing a pattern language that supports both the development and improvement of educational applications.

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

II. Systematic Mapping: an Overview

Systematic mapping is a type of secondary study that provides a process for a broader review of primary studies and whose objective is, from the relevant primary studies discovered, the obtaining of a broad overview of the research area. The aim is to identify the evidences available, as well as gaps in primary studies and areas where more primary studies must be conducted [5]. The systematic mapping follows the guidelines proposed by Petersen et al. [6], which establish the steps show in Figure 1.

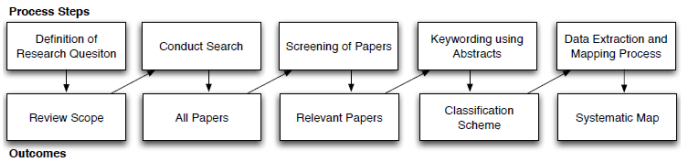

Fig. 1. The Systematic Mapping Process [6]

A. Definition of Research Questions / Review Scope

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

Aiming to achieve the established goals, we defined a protocol to guide the mapping, fully available at icmc.usp.br/e/4fc02, in which we defined the following research questions:

RQ1: What pedagogical patterns have been used?
RQ2: What problem or challenge these pedagogical patterns aim to solve or mitigate?

B. Conduct Search for Primary Studies / All Papers

The primary studies are identified by using search strings on scientific databases or browsing manually through relevant conference proceedings or journal publications. A good way to create the search string is to structure them in terms of population, intervention, comparison, and outcome [6]. Therefore, we have additionally used the PICOC criteria, proposed by Petticrew and Roberts [7], to frame the research questions.

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

For this mapping, the string was defined also by attaching terms of greater relevance to research, namely: pedagogical pattern, pedagogical patterns, educational pattern, educational patterns, learning pattern, learning patterns, teaching pattern and teaching patterns. The search terms and their synonyms were defined according to experts' opinions, the literature and the research questions set. 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")

We performed searches in the following databases: ACM, EI Compendex, IEEE Xplore Digital Library, ISI Web of Science, Science@Direct, Scopus and Springer Link. We adapted the generic search string for each database selected in accordance with its specificities and obtained 5944 studies, from which 1692 were automatically eliminated because they were identified by the support tool as duplicates. The amount of studies found at each database is shown in Table II. From the 4252 remainder studies, we proceeded to the next step.

TABLE II
STUDIES FOUND PER RESEARCH DATABASE

Research database	URL	Total of studies
ACM Digital Library	http://portal.acm.org	135 (2,27%)
EI Compendex	http://www.engineeringvillage.com	854 (14,37%)
IEEE Digital Library	http://ieeexplore.ieee.org	360 (6,06%)
ISI Web of Science	http://www.isiknowledge.com	716 (12,05%)
Science@Direct	http://www.sciencedirect.com	126 (2,12%)
Scopus	http://www.scopus.com	1291 (21,72%)
Springer Link	http://link.springer.com	2462 (41,42%)
Total		*5944 (100%)*

C. Screening of Papers for Inclusion and Exclusion / Relevant Papers

After defining the generic search string, we defined the supporting criteria for the screening of papers during the mapping execution. Such a definition aimed at the selection, among the works obtained from the automatic search, of those that show potential to answer the research questions and are directly related to the subject studied. The inclusion criterion is: Primary studies that have at least one full pedagogical pattern; and the exclusion criteria are the following: Primary studies that do not involve the issue of research questions; primary studies that are not available for download; primary studies that are neither in English, nor in Portuguese; duplicated studies; and cover files and proceedings index. It is worth mentioning that we decided not to filter the results by year to assure that no important study would be missing. Among the 4252 studies analyzed, 35 were selected for the next step.

D. Keywording of Abstracts / Classification Scheme

In this step, we have followed the reviewers read abstracts and looked for keywords and concepts that reflect the contribution of the paper. Also, the context of the research is identified and this helps the reviewers defining what data will 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 choose an existing classification of research approaches by Wieringa et al. [8], which proposes these types of research: Validation Research, Evaluation Research, Solution Proposal, Philosophical Papers, Opinion Papers, Experience Papers. The pattern category facet structured the patterns according to their specific application. The categories of this facet were built interactively, as the selected articles were being read.

E. Data Extraction and Mapping of Studies / Systematic Map

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

TABLE III
DATA EXTRACTION FORM

Data Item	Value	RQ
Study ID	Letter 'S' followed by an integer	
Article Title	Name of the article	
Author(s) Name	Set of 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 using the pattern	RQ2
Research Type	Classification of the research according to Wieringa et al. [8]	
Pattern Category	Pedagogical application of the pattern	

III. Pedagogical Patterns Map

For better readability, the table generated according to the data extraction form will be presented separately.

Firstly, we present the 35 selected studies and their information in Table IV.

Afterwards, we present all the patterns found and the problems they solve in Tables V, VI and VII. It is worth highlighting that study S20 was not mentioned in Tables V, VI and VII because it is the second part of S19 and introduces new pattern names, which authors changed based on feedback from different reviewers, but the patterns are the same above mentioned.

- Holistic Pattern Understanding became Pattern Understanding
- Experience of Benefits became Experience Advantage
- Experience of Problems became Experienced Problem
- Discover Your Own Pattern became Pattern Discovery

Study S22 is also not mentioned because it subsumes two earlier conference papers (S19 and S20).

Table VIII shows how the selected studies were categorized concerning the research type. We can notice that 91.4% 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 the researchers are proposing several patterns but there is still a gap concerning their validation and evaluation.

Table IX shows how the 109 patterns extracted from the studies above mentioned were categorized concerning their pedagogical application. We can notice that three categories are highlighted: "Deficiencies identification" (11%), "Established educational and learning processes" (21.1%) and "Motivation" (8.3%). These results reflect the reality considering the major difficulties in teaching environments, both with respect to the teacher and the student.

Finally, Figure 2 shows the relationship between Research type (Table VIII) and Pattern Category (Table IX of 109 patterns extracted from 35 studies.

IV. Related Work

To the best of our knowledge, there is no complete and well-defined pedagogical patterns map and our work intends to be a step forward in this direction. Its main contribution 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 educational systems.

In this context, we point out two important studies from Bergin et al. [2] and Köppe [44]. The first is the result of the efforts of many authors to build a pattern language based on their work. Some patterns from the Pedagogical Patterns Project[1] were revised and rewritten in Alexandrian form [45]. The currently available patterns on this pattern language focus on a classroom situation 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, the inventory format is different from the one we have adopted. Furthermore, our work is not limited to lectures.

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

V. Conclusions and Future Work

In this paper, we presented a pedagogical patterns map to be considered in the design of educational applications. The pedagogical patterns approach has been motivated by the need to exchange knowledge and good practices between research literature and the real world, as a way to support practitioners and as a means of communication among various 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.

It is worth mentioning that, in spite of the fact that systematic mappings are more accurate than other approaches, there are some threats to its validity. We can highlight the low rate of selected studies: only 0.59% of the studies extracted from the database had meaningful information. This occurred because the terms used to define our search string are also terms used in several others 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" [46].

As future work, we aim at the establishment of a pedagogical pattern language whose main objective is to help during the design of mobile learning applications, to avoid or diminish the problems found.

Acknowledgment

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References

[1] C. Alexander, *The Timeless Way of Building*. New York: Oxford University Press, 1979.

[2] J. Bergin, J. Eckstein, M. Volter, M. Sipos, E. Wallingford, K. Marquardt, J. Chandler, H. Sharp, and M. L. Manns, *Pedagogical Patterns: Advice For Educators*. Joseph Bergin Software Tools, 2012.

[3] K. Svetlana and Yonglk-Yoon, "Adaptation e-Learning Contents in Mobile Environment," in *Proceedings of the 2nd International Conference on Interaction Sciences: Information Technology, Culture and Human*. ACM, 2009, pp. 474–479.

[4] J. Roschelle and R. Pea, "A walk on the WILD side: How wireless handhelds may change computer-supported collaborative learning," *International Journal of Cognition and Technology*, vol. 1, no. 1, pp. 145–168, 2002.

[5] B. Kitchenham and S. Charters, "Guidelines for performing Systematic Literature Reviews in Software Engineering," Keele University and Durham University Joint Report, Tech. Rep. EBSE 2007-001, 2007.

TABLE IV
SELECTED STUDIES

ID	Title	Author(s) Name	Year	Reference
S01	Patterns in teaching software development	Angster, E.; Bergin, J. & Sipos, M.	2003	[9]
S02	The Potential of Christopher Alexander's Theory and Practice of Wholeness: Clues for Developing an Educational Taxonomy	Bauer, R. & Baumgartner, P.	2010	[10]
S03	Applying and developing patterns in teaching	Bennedsen, J. & Eriksen, O.	2003	[11]
S04	The Reinforcement Pedagogical Pattern for Industrial Training	Berenbach, B. & Konrad, S.	2008	[12]
S05	Active Learning and Feedback Patterns: Version 4	Bergin, J.	2006	[13]
S06	The "Instructed-teacher": A Computer Science Online Learning Pedagogical Pattern	Bower, M.	2008	[14]
S07	Interaction design patterns for classroom environments	Breuer, H.; Baloian, N.; Sousa, C. & Matsumoto, M.	2007	[15]
S08	Patterns as a paradigm for theory in community-based learning	Carroll, J. M. & Farooq, U.	2007	[16]
S09	A hybrid system of pedagogical pattern recommendations based on singular value decomposition and variable data attributes	Cobos, C.; Rodriguez, O.; Rivera, J.; Betancourt, J.; Mendoza, M.; LeóN, E. & Herrera-Viedma, E.	2013	[17]
S10	Cog-Learn: An e-Learning Pattern Language for Web-based Learning Design	Coutinho Anacleto, J.; Talarico Neto, A. & Neris, V. P. d. A.	2009	[18]
S11	A Pedagogical Pattern for Bringing Service into the Curriculum via the Web	Erickson, C. & Leidig, P.	1997	[19]
S12	Creative Education Patterns: Designing for Learning by Creating	Harashima, Y.; Kubota, T. & Iba, T.	2014	[20]
S13	Learning Patterns: A Pattern Language for Creative Learning II	Iba, T. & Miyake, T.	2010	[21]
S14	Pedagogical Patterns for Creative Learning	Iba, T.; Ichikawa, C.; Sakamoto, M. & Yamazaki, T.	2011	[22]
S15	Learning Patterns III: A Pattern Language for Creative Learning	Iba, T. & Sakamoto, M.	2011	[23]
S16	P2N: A Pedagogical Pattern for Teaching Computer Programming to Non-CS Majors	Jiang, Z.; Fernandez, E. B. & Cheng, L.	2011	[24]
S17	Developing a Pedagogical Infrastructure for Teaching Globally Distributed Software Development	Keenan, E. & Steele, A.	2011	[25]
S18	Continuous Activity: A Pedagogical Pattern for Active Learning	Köppe, C.	2011	[26]
S19	A Pattern Language for Teaching Design Patterns (Part 1)	Köppe, C.	2011	[27]
S20	A Pattern Language for Teaching Design Patterns (Part 2)	Köppe, C.	2011	[28]
S21	A Pattern Language for Teaching in a Foreign Language: Part 1	Köppe, C. & Nijsten, M.	2012	[29]
S22	A Pattern Language for Teaching Design Patterns	Köppe, C.	2013	[30]
S23	Guided Exploration: An Inductive Minimalist Approach for Teaching Tool-related Concepts and Techniques	Köppe, C. & Rodin, R.	2013	[31]
S24	Improving Students' Learning in Software Engineering Education Through Multi-level Assignments	Köppe, C. & Pruijt, L.	2014	[32]
S25	Lecture Design Patterns: Improving the Beginning of a Lecture	Köppe, C. & Portier, M.	2014	[33]
S26	Lecture Design Patterns: Laying the Foundation	Köppe, C. & Schalken-Pinkster, J.	2015	[34]
S27	Continuous Feedback Pedagogical Patterns	Larson, K. A.; Trees, F. P. & Weaver, D. S.	2008	[35]
S28	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, J.; Meyer, P. & Ruda, N.	2015	[36]
S29	Guess my X and other techno-pedagogical patterns: toward a language of patterns for teaching and learning mathematics	Mor, Y.	2010	[37]
S30	What learners teach us: e-learning patterns for adult ICT education	Rogier, E.; Uras, S. & van der Veer, G.	2013	[38]
S31	Pattern for Graduate Student Company	Ruskov, P.; Stoycheva, M. & Todorova, Y.	2010	[39]
S32	Patterns for Teaching Software in Classroom	Schmolitzky, A.	2007	[40]
S33	Learner-centered software engineering education: From resources to skills and pedagogical patterns	Seffah, A. & Grogono, P.	2002	[41]
S34	Pedagogical patterns—successes in teaching object technology: a workshop from OOPSLA'96	Sharp, H.; Manns, M. L.; McLaughlin, P.; Prieto, M. & Dodani, M.	1996	[42]
S35	Blended learning patterns for course design	Smith, S.; Dekhane, S. & Napier, N.	2010	[43]

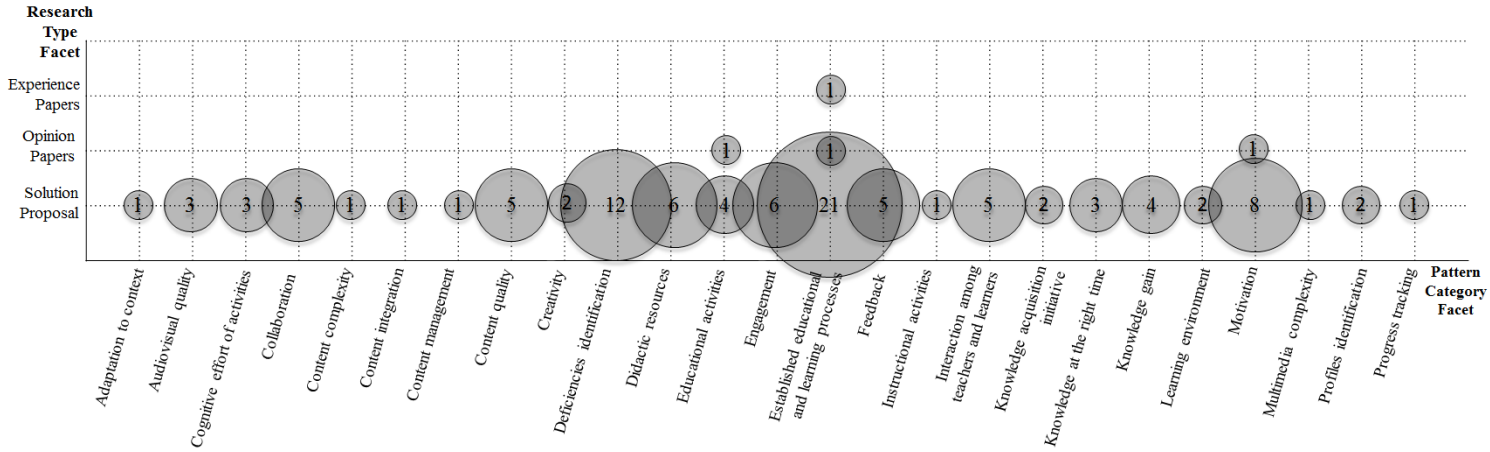

Fig. 2. Systematic Map

[6] K. Petersen, R. Feldt, S. Mujtaba, and M. Mattsson, "Systematic mapping studies in software engineering," in *Proceedings of the 12th International Conference on Evaluation and Assessment in Software Engineering*, ser. EASE'08. Swinton, UK, UK: British Computer Society, 2008, pp. 68–77. [Online]. Available: http://dl.acm.org/citation.cfm?id=2227115.2227123

[7] M. Petticrew and H. Roberts, *Systematic Reviews in the Social Sciences: A Practical Guide*. Blackwell Publishing, 2006.

TABLE V
PATTERNS AND PROBLEMS EXTRACTED FROM STUDIES - PART 1

Pattern ID	Study ID	Pattern name	Problem
P01	S01	Restructuration	Teaching concepts and methodologies outdated
P02	S02	Ball Bearing (alias: Double Circle, Onion, Zipper)	Presentations in face-to-face training are too exhaustive
P03	S03	Lay of the Land	Apathy to a topic if its overview is not well presented
P04	S03	Fill in the blanks	How to allow students working in larger project without overwhelming them
P05	S04	Reinforcement	Unable to determine comprehension through traditional methods, no immediate feedback available and the material may be difficult to understand
P06	S05	Immediate Feedback	Need to know if it is time to move to another topic/activity or if students are lost
P07	S05	Final Learning Check	Many times an individual class will have many parts, some of which are complex, and students may not have the ideas in mind
P08	S05	Student Extends	Students and instructors often find that the provided materials don't meet their needs
P09	S05	Icebreaker	If the students don't know one another their early interactions will be awkward and they will have little trust in one another's abilities to contribute
P10	S06	Instructed-Teacher	How to expose, develop and share student's mental models in virtual classroom environments in a practical and relevant way that allows students to effectively integrate all types of knowledge
P11	S07	Open (White) Space	Problem-oriented or constructivist learning should emphasize students' self-directed activities and start with students' construction and discussion, but most technologies in the classroom support a teacher centered approach
P12	S07	Gesture-Based Interaction	Dealing with small and big screen devices in order to keep user input and system response in the same space
P13	S07	Change Mode	The more gestures a system supports the more difficult it becomes to differ gestures from drawing within a single interaction mode
P14	S08	Informal developmental learning	Lack of control over IT
P15	S09	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
P16	S10	Linkage	How can the teacher introduce students to a new topic?
P17	S10	Knowledge View	How can the teacher introduce new concepts to the students?
P18	S10	In Practice	How can teachers exemplify the recently shown concept in the students' environment?
P19	S10	Top-Down	How to introduce a concept that has a large number of subitems?
P20	S10	Means the Same	How to make the student see how the topic is connected to the main goal of the lecture and to understand how the concepts are connected.
P21	S10	Knowledge Retention	How to keep newly acquired knowledge continuously working in the student's short term memory, while she prepares to learn more
P22	S11	NPO Website Service Project	How to benefit students from the experience of working on a diverse team, doing a project for a customer with real requirements and interests
P23	S12	Editing Discovery	The meeting often ends without settlement of opinions, just with various opinions
P24	S12	Celebrate Together	Some learners can't feel the project is as their own
P25	S12	Provoke for High Quality	Learners are not passionate about their creation
P26	S12	Open the Project	It is difficult to decide assessment for the learners from the objective view
P27	S13	Learning Design	It is not easy to learn how to learn, while it is na essential ability in a complex changeable society
P28	S13	Brain Switch	Thinking tends to be leaning to only logic or intuition, which each is not enough to achieve a breakthrough
P29	S13	Community of Learning	Individual's capacity is limited
P30	S13	Acceleration to Next	It frequently happens that people slack off their efforts subconsciously just before the goal
P31	S14	Discovery-Driven Expanding	If you introduce collaborative learning as a way for learner-centered learning suddenly, it is difficult for learners to perform and learn from their experience effectively.
P32	S14	Challenging Mission	There are many missions that tend to be unsuitable to creative learning because they either make learners too free and unfocused
P33	S14	Generative Participant	Communication for the collaboration doesn't always go smoothly, and often stops and sometimes falls into the situation where a very few members control the ow and others follow it
P34	S15	Design Your Learning	It is not easy to learn how to learn
P35	S15	Making Opportunities	There are few good opportunities for learning compared with your expectations
P36	S15	Creative Project	Maybe you are unwilling to learn just by acquiring knowledge and skills
P37	S15	Open-Process Learning	Learning tends to be closed and it is difficult to deepen your understanding only by yourself
P38	S15	Embodied Skills	It is not enough to memorize the "how to"
P39	S15	Language Shower	To master languages is tough
P40	S15	Tangible Piles	It is not easy to keep yourself motivated to learn
P41	S15	Thinking in Action	It is difficult to get out of the situation when you are stuck
P42	S15	Prototyping	You cannot clarify an image of what you will create
P43	S15	Field Diving	You cannot touch upon reality only by referring to documents
P44	S16	P2N: Pedagogical Pattern for Teaching Programming to Non-CS Majors	When teaching the entry-level programming course with material more advanced than the standard ones, the time of learning and for practice becomes short and the students may not have enough time
P45	S17	Remote Testing	Difficulty to teach students how to delegate the test to a remote team
P46	S17	Subordinate Role	Difficulty to teach students how to delegate the implementation to the subordinate remote team
P47	S17	Partitioning	Difficulty to teach students how to break a large project into discrete components which are each assigned to remote teams who are responsible for their respective design and implementation
P48	S17	Continuous Development	Difficulty to teach students how to supplement their resources with those of the remote team
P49	S18	Continuous Activity	If students get an assignment and a deadline, they mostly start too late to work on the assignment and they often are not able to finish the assignment in the best possible quality and on time
P50	S19	Holistic Pattern Understanding (alias: Understand Design Patterns)	Patterns are conceptually different from other design techniques or methods, and not taking this into account when teaching them often results in students applying patterns in an inappropriate way
P51	S19	Context, Problem and Consequences First (alias: First Things First, Focus Beyond The Solution)	Students who start to learn patterns often go straight to the solution and apply it, hastily skipping the problem, context, forces, and consequences parts of the pattern
P52	S19	Experience of Problems (alias: Feel The Pain)	Students often apply patterns without understanding why the problem really is a problem and they are not aware of the consequences if this problem is not addressed properly

TABLE VI
PATTERNS AND PROBLEMS EXTRACTED FROM STUDIES - PART 2

Pattern ID	Study ID	Pattern name	Problem
P53	S19	Best Fitting Pattern Choice (alias: Perfect Fit)	Students often choose inappropriate patterns without exploring if the problem they have is the same as the problem addressed by the pattern. And even if this fits, the context or forces may be different or the consequences are worse than the original problem. If pattern names are part of the vocabulary of a domain, choosing an inappropriate pattern also leads to miscommunication
P54	S19	Experience of Benefits (alias: Rewarding Sweets)	It is hard for students to see the advantages generated by correctly applied pattern solutions if they are only told to them. This has negative impact on the intrinsic motivation of the students to use patterns outside of the educational setting
P55	S19	Pattern Implementation Matters (alias: Implementation Matters)	The students have difficulties with implementing the solutions of patterns if they only read or hear about them. It is hard for them to add the information necessary for the pattern implementation, which has been abstracted away during the definition of the pattern
P56	S19	Simplicity Above Patterns (alias: Keep it Simple)	While learning patterns students want to show that they understand the patterns by implementing as many of them as possible and most often this adds unnecessary complexity without adding value
P57	S19	Principle-Supporting Pattern Usage (alias¿ Principles Are Leading)	While learning design patterns students often focus on the implementation of the patterns in isolation, which regularly results in a bad overall design
P58	S19	Discover Your Own Pattern (alias: Pattern Discovery)	Students see patterns as something that intelligent people have written. They don't understand that these mostly are captured "best known practices" and that experienced people use them without thinking about them
P59	S21	Input Selection	Available material often differs in both language levels and comprehensibility, and can be too difficult or too easy for students. Both cases will lead to problems during the course
P60	S21	Lucky Language Clover (alias: The Four Skills)	Exposing the students to language comprehension only — reading and listening — is not sufficient for creating a lasting effect in learning the foreign language. They might be able to understand content input, but unable to produce content output in the foreign language.
P61	S21	Metatalk	Students are not aware of their foreign language shortcomings and keep using incorrect language constructs and terms.
P62	S21	Language Role Model	Learning is also imitating, but imitating incorrect language usage of a teacher will affect the students' learning of the language negatively.
P63	S21	Language Status Quo	Without knowing the actual level of foreign language competences of the students it is likely that the language parts of the course design are either too difficult for the students which hinders them in grasping the content or are too simple for them which means that their language understanding probably does not improve.
P64	S21	Content-Obligatory Language	Some lexical items and terminology of the foreign language are so closely related to the content of a course that mastering them is crucial to students in order to achieve the course objectives.
P65	S21	Content-Compatible Language (alias: Content-Complementary Language)	Only mastering the obligatory language of a course's content limits the students in their expressiveness and does not improve the overall quality of students' language skills, even though it might be sufficient to fulfill the course's requirements.
P66	S21	Commented Action (alias: Think Aloud Protocol, Show and Tell)	The vocabulary and expressiveness of the students will not increase if the students only see the activities done by the teacher. They might be able to execute them themselves, but will have difficulties describing in the foreign language what they are doing.
P67	S21	Language Monitor (alias: Formative Assessment)	Judging the progress students make with language acquisition is not possible during lecturing, but without judgement you don't know if the students make progress with language acquisition.
P68	S23	Respect User Roles	Providing all functionality to all users gives some of the users the possibility to work with parts of the application they're not allowed to work with.
P69	S24	Multi-Level Assignment	Student learning is suboptimal when assignments can be completed by merely applying techniques and concepts without requiring a deeper conceptual understanding of them. In that case the students might learn less than they could have.
P70	S25	Clear Starting Signal	When the lecture begins, many students are still focused on other activities than the lecture at hand. Such a beginning is not of much value for both students and lecturer.
P71	S25	Surprise Beginning	Even though all students are aware of the start of the lecture, some are still stuck in their old thoughts and have difficulties focusing their attention on the lecturer and the lecture.
P72	S25	Emphasize Relevance First	If students do not have the feeling that they get something of value in your lecture, then they're likely to drop out fast and the lecture becomes a burden—for both teacher and students.
P73	S25	Preparation Material Check	Students often do not study the required material or content before class and are therefore not prepared sufficiently for the next lecture. This generally lowers students' learning and also disturbs your lecture planning.
P74	S25	Late Attendant Discouragement	Late attendants, especially in small classrooms or lecture halls with doors near the lecturer, can be quite disturbing. Not only do they miss part of the lecture, they can disturb the flow of the lecture and break the concentration of other attending students.
P75	S26	Suitable Content Selection	Lectures often do not fit the capabilities and interests of students, they are either boring or overwhelming. In both cases students won't remember much after the lecture, therefore it was of no value for them.
P76	S26	Suitable Delivery Form Selection	Lectures in which the content is presented in a flow of speech of the lecturer are a challenge for the students' span of attention. It is also of no value if a lot of information is presented in a way that the students find hard to understand or in a way that does not help them grasping the content.
P77	S26	Regular Attention Recuperation	Students often find it hard to follow your lecture over a longer period. They fade away in their thoughts or start to do other things. Everything you tell or do at such moments is very likely to be fruitless.
P78	S26	Lecture Structuring	Students do not learn much in a lecture if all the content is completely presented, but in isolated and unordered pieces.
P79	S26	Imagination Stimulation	Being presented just pure facts and step-by-step instructions is boring for students. Providing the content in a well structured way does not support student learning by itself.
P80	S27	Learning Contract	Students do not accept responsibility for their own learning and tend to hold the teacher or other external factors accountable for a low grade.
P81	S27	Minimum Distance	A traditional classroom or lecture hall provides a built-in spatial separation between most of the students and the lecturing instructor that can be interpreted by the student as disinterest on the part of the instructor.
P82	S27	Carefully Crafted Questions	Instructors often ask questions that fail to achieve the desired goals of the lesson.
P83	S27	Simple Answer	The instructor is not getting immediate verbal feedback from the students during a lesson.
P84	S27	Open Ended Questions	Students fail to demonstrate higher level thinking skills during class.
P85	S27	Think...Pair...Share	Students' focus is not on the lesson.
P86	S27	Pregnant Pause	Teachers and lecturers ask questions of their audience yet do not give them time to formulate a response.
P87	S27	Uninterrupted Listening	The teacher assumes what the student is going to say and interrupts, not allowing the student to complete his or her thought.
P88	S27	Three Stars and a Wish	You need a way to correct student errors and give feedback without causing your students to become defensive, disheartened, or angry.

TABLE VII
PATTERNS AND PROBLEMS EXTRACTED FROM STUDIES - PART 3

Pattern ID	Study ID	Pattern name	Problem
P89	S27	Hands Free Help	Students experience difficulties solving problems and want the solution given to them instead of drawing on their past experiences and prior knowledge to solve the problem on their own.
P90	S27	Line of Reasoning	A student catches you off guard by presenting a solution to a problem or answering a question in a way you didn't anticipate.
P91	S27	Honest Appraisal	Students don't always make connections between new material and previously learned concepts. They don't take time to think about how this new material might be applicable to their interests and goals.
P92	S27	Piece of Mind	Students don't readily give feedback regarding their perceived progress in class, the concepts they are struggling with, what they might need to be successful, and/or what has helped them succeed so far.
P93	S28	Right People for Right Problems	For an ambitious service learning project to be successful, it is essential that the students involved have a motivation to participate.
P94	S28	Improve Students' Cooperation Skills	The problem arises when students work in personal cooperation with a community partner organization, what they usually do in service learning projects.
P95	S28	Attract Unbiased Teaching Staff	It is always a challenge to encourage teaching staff to use new innovative methods, most of all if they have been in their position for a long period of time.
P96	S29	Mathematical Game Pieces	How do you design (or choose) a game to convey mathematical ideas in an effective and motivating manner? How do you judge if a proposed game is an adequate tool for teaching particular mathematical concepts?
P97	S29	Guess My X	A teacher wants to design a game for learning concepts, methods and meta-cognitive skills in a particular mathematical domain. This game should use a combination of available technologies. Many complex concepts require an understanding of the relationship between the structure of an object and the process which created it. Novices may master one or the other but find it challenging to associate the two.
P98	S29	Soft scaffolding	How do you provide direction and support while maintaining the learners' freedom, autonomy and sense of self, as well as the teachers' flexibility to adapt?
P99	S29	Narrative spaces	How can the epistemic power of narrative be harnessed by educators and learners in the construction of mathematical meaning?
P100	S29	Objects to talk with	Most computer-mediated discussion tools are strongly text-oriented, prompting users to express their thoughts lucidly in words or symbols. Yet two important elements of natural conversation are lost: the embodied dimension, i.e. gestures, and the ability to directly reference the objects of discussion.
P101	S30	Video lecture	Students want to follow a lecture with a teacher but have no (more) physical access to the teacher.
P102	S31	Graduate Student Company Pattern	How does one motivate and educate science and technical student to have entrepreneurial competences and attitude.
P103	S32	Show It Running	Slides are mainly static, using software is dynamic; thus slides are typically not well suited to capture the characteristics of software.
P104	S32	Show Programming	Programming is a unique interplay of static properties (at writing time) and dynamic properties (at execution time) that is hard to capture with slides; quite often, subtle variations can have major effects.
P105	S32	Group Design Challenge	Learners will not understand abstract design or programming concepts well without applying the imparted knowledge; but if they apply it on their own they do not get immediate and qualified feedback on their work which can manifest wrong understandings.
P106	S32	Learners Do Challenge	You want to engage the learners as much as possible and use the time of the course as effectively as possible.
P107	S33	Design-Implement-Redesign-Reimplement (DIRR)	It is hard to explain new concepts and methods based on old concepts and also often hard to get students to make the paradigm shift from functional programming to object oriented programming.
P108	S34	Explore-Present-Interact-Critique (EPIC)	Two of the most important abilities of software developers are to be able to learn new material efficiently and to be able to share knowledge and insights with the other members of the work group. How to train them? This pattern allows the students to acquire these abilities by forcing them into being the teacher for themselves.
P109	S35	Independent Learning	Students may not be motivated to complete reading assignments that lead to in-class activities.

TABLE VIII
RESEARCH TYPE DISTRIBUTION

Research type	Amount	Studies
Experience Papers	1	S34
Opinion Papers	2	S01, S03
Solution Proposal	32	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, S33, S35

[8] R. Wieringa, N. Maiden, N. Mead, and C. Rolland, "Requirements engineering paper classification and evaluation criteria: a proposal and a discussion," *Requirements Engineering*, vol. 11, no. 1, pp. 102–107, 2006.

[9] E. Angster, J. Bergin, and M. Sipos, "Patterns in teaching software development," in *Object-Oriented Technology. ECOOP 2003 Workshop Reader*. Springer, 2003, pp. 130–142.

[10] R. Bauer and P. Baumgartner, "The potential of christopher alexander's theory and practice of wholeness: Clues for developing an educational taxonomy," in *Proceedings of the 15th European Conference on Pattern Languages of Programs*, ser. EuroPLoP '10. New York, NY, USA: ACM, 2010, pp. 12:1–12:21. [Online]. Available: http://doi.acm.org/10.1145/2328909.2328924

[11] J. Bennedsen and O. Eriksen, "Applying and developing patterns in teaching," in *Frontiers in Education, 2003. FIE 2003 33rd Annual*, vol. 1. IEEE, 2003, pp. T4A–2.

[12] B. Berenbach and S. Konrad, "The reinforcement pedagogical pattern for industrial training," in *Requirements Engineering Education and Training, 2008. REET'08.* IEEE, 2008, pp. 1–5.

[13] J. Bergin, "Active learning and feedback patterns: Version 4," in *Proceedings of the 2006 Conference on Pattern Languages of Programs*, ser. PLoP '06. New York, NY, USA: ACM, 2006, pp. 6:1–6:6. [Online]. Available: http://doi.acm.org/10.1145/1415472.1415479

[14] M. Bower, "The "instructed-teacher": A computer science online learning pedagogical pattern," in *Proceedings of the 13th Annual Conference on Innovation and Technology in Computer Science Education*, ser. ITiCSE '08. New York, NY, USA: ACM, 2008, pp. 189–193. [Online]. Available: http://doi.acm.org/10.1145/1384271.1384323

[15] H. Breuer, N. Baloian, C. Sousa, and M. Matsumoto, "Interaction design patterns for classroom environments," in *Human-Computer Interaction. HCI Applications and Services*. Springer, 2007, pp. 163–172.

[16] J. M. Carroll and U. Farooq, "Patterns as a paradigm for theory in community-based learning," *International Journal of Computer-Supported Collaborative Learning*, vol. 2, no. 1, pp. 41–59, 2007.

[17] C. Cobos, O. Rodriguez, J. Rivera, J. Betancourt, M. Mendoza, E. LeóN, and E. Herrera-Viedma, "A hybrid system of pedagogical pattern recommendations based on singular value decomposition and variable data attributes," *Information Processing & Management*, vol. 49, no. 3, pp. 607–625, 2013.

[18] J. Coutinho Anacleto, A. Talarico Neto, and V. P. d. A. Neris, "Cog-learn: An e-learning pattern language for web-based learning

TABLE IX
PATTERN CATEGORY DISTRIBUTION

Pattern category	Amount	Patterns
Adaptation to context	1	P41
Audiovisual quality	3	P11, P12, P13
Cognitive effort of activities	3	P54, P55, P56
Collaboration	5	P31, P33, P37, P74, P94
Content complexity	1	P78
Content integration	1	P64
Content management	1	P14
Content quality	5	P08, P53, P58, P59, P75
Creativity	2	P32, P36
Deficiencies identification	12	P07, P29, P39, P45, P46, P47, P48, P52, P57, P61, P84, P91
Didactic resources	6	P44, P96, P97, P101, P103, P104
Educational activities	5	P04, P42, P43, P66, P69
Engagement	6	P70, P71, P77, P80, P85, P106
Established educational and learning processes	23	P01, P05, P10, P16, P17, P18, P19, P20, P23, P26, P27, P28, P34, P38, P50, P60, P76, P79, P82, P95, P99, P107, P108
Feedback	5	P06, P83, P88, P92, P105
Instructional activities	1	P22
Interaction among teachers and learners	5	P09, P62, P86, P87, P98
Knowledge acquisition initiative	2	P35, P90
Knowledge at the right time	3	P49, P51, P89
Knowledge gain	4	P15, P21, P65, P73
Learning environment	2	P68, P81
Motivation	9	P02, P03, P24, P25, P40, P72, P93, P102, P109
Multimedia complexity	1	P100
Profiles identification	2	P30, P63
Progress tracking	1	P67

design," *eLearn*, vol. 2009, no. 8, Aug. 2009. [Online]. Available: http://doi.acm.org/10.1145/1595390.1595437

[19] C. Erickson and P. Leidig, "A pedagogical pattern for bringing service into the curriculum via the web," in *Proceedings of the 2Nd Conference on Integrating Technology into Computer Science Education*, ser. ITiCSE '97. New York, NY, USA: ACM, 1997, pp. 54–56. [Online]. Available: http://doi.acm.org/10.1145/268819.268837

[20] Y. Harashima, T. Kubota, and T. Iba, "Creative education patterns: Designing for learning by creating," in *Proceedings of the 19th European Conference on Pattern Languages of Programs*, ser. EuroPLoP '14. New York, NY, USA: ACM, 2014, pp. 7:1–7:10. [Online]. Available: http://doi.acm.org/10.1145/2721956.2721989

[21] T. Iba and T. Miyake, "Learning patterns: A pattern language for creative learning ii," in *Proceedings of the 1st Asian Conference on Pattern Languages of Programs*, ser. AsianPLoP '10. New York, NY, USA: ACM, 2010, pp. 4:1–4:6. [Online]. Available: http://doi.acm.org/10.1145/2371736.2371742

[22] T. Iba, C. Ichikawa, M. Sakamoto, and T. Yamazaki, "Pedagogical patterns for creative learning," in *Proceedings of the 18th Conference on Pattern Languages of Programs*, ser. PLoP '11. New York, NY, USA: ACM, 2011, pp. 28:1–28:6. [Online]. Available: http://doi.acm.org/10.1145/2578903.2579165

[23] T. Iba and M. Sakamoto, "Learning patterns iii: A pattern language for creative learning," in *Proceedings of the 18th Conference on Pattern Languages of Programs*, ser. PLoP '11. New York, NY, USA: ACM, 2011, pp. 29:1–29:8. [Online]. Available: http://doi.acm.org/10.1145/2578903.2579166

[24] Z. Jiang, E. B. Fernandez, and L. Cheng, "P2n: A pedagogical pattern for teaching computer programming to non-cs majors," in *Proceedings of the 18th Conference on Pattern Languages of Programs*, ser. PLoP '11. New York, NY, USA: ACM, 2011, pp. 25:1–25:9. [Online]. Available: http://doi.acm.org/10.1145/2578903.2579163

[25] E. Keenan and A. Steele, "Developing a pedagogical infrastructure for teaching globally distributed software development," in *Proceedings of the 2011 Community Building Workshop on Collaborative Teaching of Globally Distributed Software Development*, ser. CTGDSD '11. New York, NY, USA: ACM, 2011, pp. 6–10. [Online]. Available: http://doi.acm.org/10.1145/1984665.1984667

[26] C. Köppe, "Continuous activity: A pedagogical pattern for active learning," in *Proceedings of the 16th European Conference on Pattern Languages of Programs*, ser. EuroPLoP '11. New York, NY, USA: ACM, 2011, pp. 3:1–3:7. [Online]. Available: http://doi.acm.org/10.1145/2396716.2396719

[27] ——, "A pattern language for teaching design patterns (part 1)," in *Proceedings of the 16th European Conference on Pattern Languages of Programs*, ser. EuroPLoP '11. New York, NY, USA: ACM, 2011, pp. 2:1–2:21. [Online]. Available: http://doi.acm.org/10.1145/2396716.2396718

[28] ——, "A pattern language for teaching design patterns (part 2)," in *Proceedings of the 18th Conference on Pattern Languages of Programs*, ser. PLoP '11. New York, NY, USA: ACM, 2011, pp. 23:1–23:16. [Online]. Available: http://doi.acm.org/10.1145/2578903.2579161

[29] C. Köppe and M. Nijsten, "A pattern language for teaching in a foreign language: Part 1," in *Proceedings of the 17th European Conference on Pattern Languages of Programs*, ser. EuroPLoP '12. New York, NY, USA: ACM, 2012, pp. 10:1–10:14. [Online]. Available: http://doi.acm.org/10.1145/2602928.2603086

[30] C. Köppe, "A pattern language for teaching design patterns," in *Transactions on Pattern Languages of Programming III*. Springer, 2013, pp. 24–54.

[31] C. Köppe and R. Rodin, "Guided exploration: An inductive minimalist approach for teaching tool-related concepts and techniques," in *Proceedings of the 3rd Computer Science Education Research Conference on Computer Science Education Research*, ser. CSERC '13. Open Univ., Heerlen, The Netherlands, The Netherlands: Open Universiteit, Heerlen, 2013, pp. 9:93–9:101. [Online]. Available: http://dl.acm.org/citation.cfm?id=2541917.2541926

[32] C. Köppe and L. Pruijt, "Improving students' learning in software engineering education through multi-level assignments," in *Proceedings of the Computer Science Education Research Conference*, ser. CSERC '14. New York, NY, USA: ACM, 2014, pp. 57–62. [Online]. Available: http://doi.acm.org/10.1145/2691352.2691357

[33] C. Köppe and M. Portier, "Lecture design patterns: Improving the beginning of a lecture," in *Proceedings of the 19th European Conference on Pattern Languages of Programs*, ser. EuroPLoP '14. New York, NY, USA: ACM, 2014, pp. 16:1–16:12. [Online]. Available: http://doi.acm.org/10.1145/2721956.2721957

[34] C. Köppe and J. Schalken-Pinkster, "Lecture design patterns: Laying the foundation," in *Proceedings of the 18th European Conference on Pattern Languages of Program*, ser. EuroPLoP '13. New York, NY, USA: ACM, 2015, pp. 4:1–4:27. [Online]. Available: http://doi.acm.org/10.1145/2739011.2739015

[35] K. A. Larson, F. P. Trees, and D. S. Weaver, "Continuous feedback pedagogical patterns," in *Proceedings of the 15th Conference on Pattern Languages of Programs*, ser. PLoP '08. New York, NY, USA: ACM, 2008, pp. 12:1–12:14. [Online]. Available: http://doi.acm.org/10.1145/1753196.1753211

[36] J. Miller, P. Meyer, and N. Ruda, "Patterns on civic engagement, service learning and campus community partnerships from the "program for the advancement of service learning and social responsibility of universities"," in *Proceedings of the 18th European Conference on Pattern Languages of Program*, ser. EuroPLoP '13. New York, NY, USA: ACM, 2015, pp. 11:1–11:10. [Online]. Available: http://doi.acm.org/10.1145/2739011.2739022

[37] Y. Mor, "Guess my x and other techno-pedagogical patterns: toward a language of patterns for teaching and learning mathematics," 2010.

[38] E. Rogier, S. Uras, and G. van der Veer, "What learners teach us: e-learning patterns for adult ict education," in *Proceedings of the 31st European Conference on Cognitive Ergonomics*. ACM, 2013, p. 8.

[39] P. Ruskov, M. Stoycheva, and Y. Todorova, "Pattern for graduate student company," in *EuroPLoP 2009: 14th Annual European conference on Pattern Languages of Programs*, vol. 566, 2010.

[40] A. Schmolitzky, "Patterns for teaching software in classroom," in *EuroPLoP 2002: 12nd Annual European conference on Pattern Languages of Programs*, 2007, pp. 37–52.

[41] A. Seffah and P. Grogono, "Learner-centered software engineering education: From resources to skills and pedagogical patterns," in *Software Engineering Education and Training, 2002.(CSEE&T 2002). Proceedings. 15th Conference on*. IEEE, 2002, pp. 14–21.

[42] H. Sharp, M. L. Manns, P. McLaughlin, M. Prieto, and M. Dodani, "Pedagogical patterns—successes in teaching object technology: a workshop from oopsla'96," *ACM SIGPLAN Notices*, vol. 31, no. 12, pp. 18–21, 1996.

[43] S. Smith, S. Dekhane, and N. Napier, "Blended learning patterns for course design," in *International Conference on Information Systems, ICIS*, vol. 10, 2010.

[44] C. Köppe, "Towards a pattern language for lecture design: An inventory and categorization of existing lecture-relevant patterns," in *Proceedings of the 18th European Conference on Pattern Languages of Program*, ser. EuroPLoP '13. New York, NY, USA: ACM, 2015, pp. 3:1–3:17. [Online]. Available: http://doi.acm.org/10.1145/2739011.2739014

[45] C. Alexander, S. Ishikawa, and M. Silverstein, *A Pattern Language: Towns, Buildings, Construction*. New York: Oxford University Press, August 1977.

[46] X. Christine Wang, D. Michelle Hinn, and A. G. Kanfer, "Potential of computer-supported collaborative learning for learners with different learning styles," *Journal of Research on Technology in Education*, vol. 34, no. 1, pp. 75–85, 2001.