# Yes You Can – Empowering Lecturers to Simulate Collaboration among Learners in the Disciplines of Problem-Solving and Critical Thinking Regardless of Class Size

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**Abstract.** Fostering higher-level learning in the disciplines of problem-solving and critical thinking becomes important when educating knowledge workers. By taking part in collaborative learning (CL) activities, e.g., interactive discussions, learners have the chance to develop, defend, and critique positions. However, implementing CL activities is often complex because this requires knowledge in designing effective collaboration. We build on insights from learning and collaboration engineering literature to develop an IT-based Collaborative-Learning-Pattern Approach (CLPA) that consists of two patterns, each describing a process design – one for training problem-solving, and the other for attaining critical thinking abilities. To evaluate the CLPA, we use simulations, walk-throughs among lecturers, and pilot-tests among students. Results show that the CLPA empowers lecturers to implement respective activities in the classroom, takes into account pedagogical demands, and satisfies lecturers as well as learners. We contribute several findings toward a design theory for empowering lecturers to implement CL activities in their classes.

**Keywords:** collaborative learning, collaborative-learning-pattern approach, higher-level learning, collaboration engineering, design science research.

## 1 Introduction

Approaches for training *higher-level learning (HLL)* on the upper levels of Bloom's taxonomy (apply, analyze, evaluate, create) [1] in the disciplines of problem-solving and critical thinking are becoming increasingly important in the digital age, which is characterized by an increasing availability of information. Furthermore, to remain competitive, innovative companies are in demand for highly educated knowledge workers. Competences such as teamwork and communication abilities are highly relevant as well [2]. The performance of knowledge workers depends on the degree to which they master those skills. Thus, universities have to provide learning experiences that help learners to develop those skills. However, traditional lectures – characterized by a low level of interaction among learners and a focus on factual knowledge [3] – are still popular. The reasons are for example declining state funding and increasing student numbers [4]. This means that learners often lack the chance to develop, defend, and critique positions, which would be vital for achieving HLL. Collaborative learning (CL) approaches ground on insights from *constructive learning theory* that posits that learning occurs by experiencing an environment through interactions with other individuals [5]. These approaches seem to be promising when it comes to overcoming existing shortcomings. However, CL approaches that focus on HLL are typically less predictive and hardly replicable, demand an understanding of how to design effective collaboration, and do not restrict learners in their experiences [6]. Lecturers lack validated out-off-the-box techniques to conduct and stimulate CL activities among learners. While lecturers struggle with less predictive and hardly replicable learner interactions and outcomes, learners struggle with CL techniques in terms of HLL tasks. These tasks provide learners with a problem situation. Such situations require that learners develop a solution that represents a sophisticated understanding of knowledge concepts and their relationships and thus, train problem-solving abilities. Furthermore, these situations require that learners analyze and evaluate the situation and, thus, train critical-thinking abilities. Inexperienced learners not familiar with these HLL learning techniques are often overstrained since e.g. tasks seem to be unclear and open-ended; instructions focus on learning content, but often do not provide training or guidance on how to proceed through the CL experience for HLL. In contrast to constructivist learning literature that argues learning processes should be ad hoc [6, 7], collaboration literature shows that process structures can under certain conditions increase the number, quality, and creativity of ideas a group creates. They may also increase the number of communication cues exchanged within a group, and improve the quality of its work products while reducing cognitive load [8]. Most individuals – lecturers as well as learners – do not have an intuitive grasp of effective collaboration. In cases of inventing ad hoc collaboration, most groups tend to be ineffective [8]. This leads to the assumption that CL experiences may benefit from systematically designed collaboration that guides lecturers and learners. Therefore, applying insights from collaboration literature to the domain of learning might be a solution. A design methodology is needed that a) provides procedural guidance on how to split structure and that describes CL activities for HLL in a way that helps lecturers and learners proceed through CL activities in a predictive and effective way; and b) helps lecturers implement CL activities for HLL as building blocks in their classes. In that context, *collaboration engineering* is an approach that designs and deploys high-value recurring tasks and transfers them to practitioners (lecturers, learners) without the ongoing support from expert facilitators [8].

The goal of this paper is to help lecturers and learners overcome this challenge by answering the following research question: *How can CL knowledge be packaged in a reusable way so that it comprises sufficient collaboration techniques to empower lecturers (and learners) to conduct (and follow) CL activities for HLL in the classroom?* The objective of this paper is to develop the *Collaborative-Learning-Pattern Approach (CLPA)* comprising two process designs inherent in patterns for enhancing HLL – the *Problem-Solving Pattern (PSP);* and the *Critical-Thinking Pattern (CTP).* The *design goals* of CLPA are: (1) to help lecturers enhance CL activities for HLL in the areas of problem-solving and critical thinking in classes in a predictive way; (2) to help learners proceed through CL activities with assisting guidance on collaboration. We focus on these two patterns for two reasons. First, they enhance cognitive processes that refer to applying, analyzing, evaluating, and creating knowledge, and thus focus on the upper levels of Bloom's taxonomy [1]; and second, they help enhance skills relevant for knowledge workers such as teamwork and communication. Each pattern represents a design for a reusable and structured collaboration process that packages sufficient collaboration expertise so that non-experts (lecturers, learners) can execute and follow a well-designed work practice without training in tools and techniques. We follow the idea of patterns, because *patterns* "[…] exist as means of deriving useful solutions to recurring problems within specific contexts" [9]. Consequently, a pattern describes a recurring problem as well as the core of the solution for that problem in such a way that the solution can be used unlimitedly [9]. To guide our design choices, we rely on insights from collaboration engineering literature and use the *six-layer-model* to design and present the CLPA with its patterns [10]. The layers comprise the definition and configuration of a group *goal*, *products*, *activities*, *procedures*, *tools*, and *behavior* [10].

## 2 Design Science Research Framework

In this paper, we report a Design Science Research (DSR) study and structure our paper along Hevner's 2007 [11] three-cycle view (Figure 1). First, we start the *relevance cycle* by identifying a set of unsolved problems inherent in packaging sufficient collaboration expertise to enhance CL activities for HLL in the classroom (activity #1 | section 1). Second, we initiate the *rigor cycle* by drawing on justificatory knowledge from CL literature with respect to training problem-solving and critical thinking abilities (activity #2 | section 3). Thirdly, we start the *design cycle* and provide principles of form and function inherent in generalizable requirements for CL activities for HLL, and the CLPA design with its two patterns as a generalizable solution (activity #3 | section 4). In section 5, we complete several iterative design and relevance cycles by describing the procedures of testing three iterative exemplar instances of the CLPA in terms of a multi-method evaluation (activity #4 – simulation with designers │ activity #5 – walk-through with lecturers │ activity #6 – pilot-test with students in the classroom). The results show that the designed artifact of CLPA meets the design goals. In section 6, we complete the rigor cycle by adding *prescriptive knowledge*[1] [12] to the literature before we close with an outlook on future research in section 7. According to Gregor's 2006 descriptions [13], our CLPA resembles a theory of '*design and action*'. More precisely, it is of the type '*improvement*'. Lecturers can use CLPA to create their own instances [12].

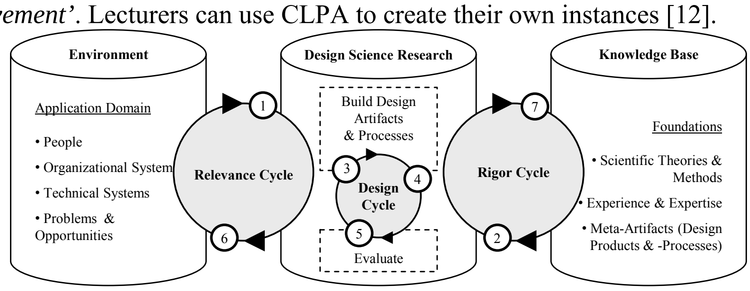


**Figure 1.** DSR Three-Cycle View in the Context of the Study

## 3 Theoretical Background of Collaborative Learning

*Collaborative learning (CL)* is based on constructivist learning theory [14]. According to this theory, learners learn from experiences that they gain through interactions with their environment and each other [15]. If well designed, CL may relieve the lecturer from some labor-intensive tasks, particularly in large classes, such as giving individual feedback on assignments. Learners benefit from such interactions in several ways: e.g. discussions can enable a direct exchange between learners that fosters reflection of knowledge, and thus, critical thinking; and can increase motivation, participation [16], and learning success [17]. This helps learners improve job-relevant competences like teamwork and communication [14]. The range of CL activities comprises discussions, co-construction of solutions, or giving mutual feedback. Literature on peer discussion of multiple-choice tasks, for example, describes positive learning effects when learners first reflect knowledge on their own, then discuss their choice with others, and finally re-evaluate their choice [18]. The co-construction of a solution, for example, helps learners explain and challenge ideas to each other, and stimulates knowledge creation [19]. Moreover, mutual assessment among learners has the potential to correct mistakes and to clarify unclear issues [20].

To enhance such CL experiences, lecturers need to respect several aspects. They have to ensure reciprocity in social interactions among learners, e.g. when it comes to direct feedback [21]. They also have to ensure that learners are responsible for their outcome [19] and that assignments and instructions are clear [22]. In a class, however, there are high- and less-experienced learners. Hence, it is hard for a lecturer to create a learning experience that challenges the top learners without losing the bottom

[1] *Prescriptive knowledge* describes artifacts designed by humans to improve the natural world. It is inherent in the form of models, methods, instantiations, and design theories.

learners. A shared understanding of knowledge concepts therefore is necessary to foster social interactions toward a development, modification, and reinforcement of shared mental models [23]. Van den Bossche et al. [24] identify *team learning behaviors* as follows: learners should express and share their individual understanding, and listen to each other (construction), discuss and clarify their understanding to reach mutual understanding (co-construction), and negotiate an agreement on a mutually shared perspective (constructive conflict). *Problem-based learning* is known to generate HLL. This is focused experiential learning that is organized around the investigation, explanation, and resolution of meaningful problems [25]. This way it refers to metacognitive knowledge on the upper levels of Bloom's taxonomy [1]. Learners collaborate in small groups and solve a problem. Depending on the assignment, the learners train *problem-solving abilities* by creating a common solution for a complex situation. They can also train *critical thinking abilities* by evaluating, analyzing, interpreting or explaining a problem situation with the aim of making a reflective judgement [26]. The lecturer facilitates and guides learners through the learning experience [27]. Although a wide range of variations of problem-based learning have evolved in literature and educational practice, there are some core characteristics: (1) learning needs to be learner-centered; (2) learning has to occur in small groups under the guidance of a tutor; (3) the tutor needs to act as a facilitator; (4) authentic problems are primarily encountered in the learning sequence, before a preparation has occurred; (5) the problems encountered are used as a tool to achieve knowledge and skills that are necessary for problem-solving [25]. Fifty years after problem-based learning had evolved; it was applied to various educational contexts. Much evidence suggests that it is more effective than traditional methods with regard to enhancing learners' problem-solving and critical thinking abilities. However, skeptics argue that it is ineffective because it provides only minimum guidance and therefore is too complex and not compatible with human cognitive architecture [28]. From a meta-study, Hmelo-Silver 2004 [27] derives a research agenda that calls for more work in the areas of collaboration, scaffolding structures for inexperienced learners, and approaches to overcome the lack of skilled facilitators. "Classrooms have more students than one person can easily facilitate, and learning to facilitate well is a challenge" [27]. She suggests techniques such as procedural facilitation or scripted cooperation to address this challenge.

# 4 The Collaborative-Learning-Pattern Approach (CLPA)

## 4.1 Generalizable Requirements to Enhance Collaborative Learning for HLL

In the following, we describe the design cycle of our study. We present generalizable requirements for enhancing CL activities for HLL (section 4.1) and then describe the CLPA with its two patterns as a generalizable solution (section 4.2). Following the DSR paradigm, we derive generalizable requirements (see Table 1) to design CL activities for HLL by completing a relevance cycle (section 1) and a rigor cycle (section 3). Based on this we derive the CLPA as our generalizable solution.

**Table 1.** Generalizable Requirements to Enhance CL Activities for HLL

| |
|---|
| **Relevance cylce – lecturers' requirements (see the specific challenges/sources in brackets):** |
| (GR 1) Set-up Guidance*:* The CLPA shall provide instructions for the task choice, as well as definition, set-up, and configuration of CL activities (lack of CL design experience of lecturers). |
| (GR 2) Facilitation Guidance: The CLPA shall provide detailed instructions on the facilitation actions, e.g. statements and questions the lecturer needs to work with during the CL experience (unpredictable moderation of CL). |
| **Relevance cylce – learners' requirements (see the specific challenges/sources in brackets):** |
| (GR 3) Simplified Process Structure*:* The CLPA shall divide CL into activities with defined subtasks (learners' resistance to open-ended and highly complex task structures). |
| (GR 4) Collaborative Interaction Support*:* The CLPA shall provide instructions on how interactions among learners should be organized in each phase (high cognitive load because of inventing ad-hoc collaboration parallel to task solving) |
| (GR 5) Clear Goal/Outcome Specifications*:* The CLPA shall define clear final and intermediate goals and outcomes for the learners for a specific task (risk to self-efficacy and satisfaction in case of transparency) |
| **Rigor cycle – collaborative learning literature:** |
| (GR 6) Individual Reflection*:* The CLPA shall support individual construction and reflection of knowledge [24]. |
| (GR 7) Mutual Feedback*:* The CLPA shall provide structured support for constructive feedback, sense making [20, 24]. |
| (GR 8) Consolidation of Solutions*:* The CLPA shall provide structured support for negotiating and consolidating different perspectives towards a shared solution [22, 24]. |
| (GR 9) Access to Solution: Exemplary solutions shall be provided to all learners or discussed after the task completion (given the partly unpredictable outcome of CL, all learners shall have the chance to receive a correct solution) [19]. |
| (GR 10) Task Responsibility in Small Breakout Groups*:* The CLPA shall assign distinct, complementary subtasks to breakout groups small enough for each learner to feel responsible for the result [19, 21]. |

### 4.2 The Pattern-Based Process Designs as a Generalizable Solution

The aim of the CLPA is to initiate predictive small-group CL activities for HLL in the disciplines of problem-solving and critical thinking. Thus, the CLPA comprises two patterns – the PSP (see section 4.2.1 [Table 3]), and the CTP (see section 4.2.2 [Table 4]). To develop and describe the CLPA we use the six-layer model [10] as a design methodology in order to apply insights from collaboration engineering literature, such as process restrictions and structuration of collaboration, to the domain of CL [10]. By following the layers we systematically derive a reusable process design for each pattern that structures CL in a sequence of activities with several outcomes. Our generalizable requirements guide our design choices. To conduct the two patterns of CLPA in a scalable manner, the lecturer has to prepare some conditions (see Table 2):

**Table 2.** General Conditions to Conduct the Patterns of CLPA

| Parameter | Description |
|---|---|
| Problem situation | Define an overall complex problem situation with action items in which the subtasks become embedded. A problem situation is a situation that covers the intended content to be learned as well as the specific and unique contextual factors to be considered, and that considers the conceptual connections of the problem within the curriculum [29]. |
| Choose and create task structure | Define 2 up to 15 independent subtasks that refer to learning objectives (task specifics described in each pattern); pay attention that its execution takes place in parallel sub-/ breakout groups. |
| Specify deliverables | Realize learning objectives within the demands of the group deliverable (e.g. visualization and explanation) and pay attention to the fact that it is easy to present in the plenary group. |
| Breakdown group structure | The whole class is the plenary group. A plenary group can be divided into at least 2 up to 15 subgroups (4 to 30 participants each), working simultaneously. A subgroup can be divided into several breakout groups (2 to 6 participants each) [30]. |
| Dependencies groups and tasks | Each participant is part of a breakout group and works on a specific subtask (number of subtasks = number of breakout groups). A subgroup receives all subtasks. |
| Scalability | The problem situation and its subtasks can be assigned to more than one subgroup and their breakout groups. Use tools that provide a shared working space for all breakout groups. |

### 4.2.1 Problem-Solving Pattern (PSP)

The *group goal* of PSP is that learners simultaneously and collaboratively clarify, discuss, and develop a solution for a subtask within two hours. To keep learners motivated, the task should be appealing to them, e.g. by being relevant for learners' future career or addressing their personal interests [29]. The collaboration helps learners to satisfy individual goals such as becoming qualified knowledge workers by experiencing HLL in the discipline of problem-solving as well as training teamwork and communication abilities. To operationalize the goal we use an instrumental *group product*: each subtask solution has to be reported as a group deliverable in the form of text and visualizations to illustrate all relevant knowledge concepts and their relationships in a correct and abstract manner and thus, new knowledge is created. To operationalize the group product we define group activities to structure the collaboration. The PSP comprises three distinct steps, each using a *thinkLet*[2] to structure *group activities*. While the learners work in a subgroup in step 1, they collaborate within breakout groups in steps 2 and 3. In step 1, each learner receives access to all subtasks. On their own, learners brainstorm solution ideas while having the chance to read the contributions from their teammates. This activates chunking and thus, cognitive mechanisms to build relationships among knowledge frames. Reading ideas from other learners triggers cognitive effects among the less-experienced learners. In step 2, learners are assigned to breakout groups, each of which receives a subtask with the deliverables from step 1. In the breakout groups, learners discuss, organize, and summarize contributions and add missing knowledge aspects. This helps them consider and juxtapose the knowledge to create a solution for a problem situation. In step 3, learners report the solution by using text descriptions and visualizations. The *tool* support provides shared writing pages (e.g., GSS with separated groups, text editing, visualizations [e.g., ThinkTank, GoogleDocs, Google Slides]; flip charts; cards) so that the learners are able to make contributions while reading the contributions from other learners (step 1), and to discuss with other learners and visualize their solution (steps 2, 3). After each step the tools generate a report of the group deliverables (e.g. list of ideas). The *group behavior* restricts learner interactions toward solving the task. After each step, learners are stopped from editing documents and become automatically assigned to their group (plenary group, subgroup, or breakout group). Learners receive guidance via clear instructions, enabling them to cope with subtasks, showing them how to complete the activities, giving them orientation, e.g. with a list of teammates. Table 3 illustrates the PSP and serves as a moderation plan.

**Table 3.** Problem-Solving Pattern (PSP): Overview and Moderation Plan

| | | | |
|---|---|---|---|
| **Learning objective** | Apply, analyze, evaluate, create | **Task specification** | Content, context, connection |
| **Individual goal** | Training HLL in the discipline of problem-solving and, teamwork and, communication abilities. | | |
| **Group product** | For each subtask a solution in the form of meaningful text and visualizations (e.g., storyline/scenes, slide show). | | |
| **Group changes** | 2: subgroup to breakout group; breakout group to plenary group | | |
| **Tool support** | GSS – functionalities for separate groups, text editing, visualizations: e.g., ThinkTank, GoogleDocs, flip charts, cards | | |

[2] *thinkLets* are packaged collaborative activities that serve as validated building blocks [33].

| | Group activity & general description | Group product & quality indicator | Group procedures (thinkLet, pattern of collaboration) [8] |
|---|---|---|---|
| **Step 1: 20 min** | Subgroups:<br>Each subgroup receives all subtasks. Each learner brainstorms ideas to create a solution for a problem situation among all subtasks. | Product: Per subgroup, a document with a set of solution ideas for each subtask.<br>Quality: Contributions are solution ideas that represent knowledge concepts in the form of meaningful keywords. | LeafHopper (brainstorm): For each subgroup a bundle of shared writing pages, each with a subtask.<br>a) Explain learners the subtasks and how to contribute.<br>b) Explain expectations regarding quality aspects of contributions.<br>c) Prompt learners to work on subtasks in which they have the most expertise; to look at each subtask, read it, and add contributions.<br>d) Indicate that learners will not be able to work on every subtask during the available time. |
| **Step 2: 40 min** | Breakout groups:<br>Subgroups are divided into breakout groups, each assigned to a subtask. Learners discuss, organize, and summarize solution aspects for a subtask. | Product: Per breakout group, a document with a clarified and summarized set of solution aspects for each subtask.<br>Quality: Organized, corrected, and completed solution aspects. | PopcornSort (organize): For each breakout group a shared writing page with a subtask.<br>a) Explain and verify instructions and converge categories (not relevant, correct, missing aspects).<br>b) Explain that contributions are to be assigned to categories?<br>c) Summarize the correct aspects in a meaningful explanation. |
| **Step 3: 60 min** | Breakout groups:<br>Learners report their solution in the form of text and visualizations.<br>Plenary group:<br>Lecturer and learners discuss exemplary solutions. | Product: Per breakout group a report for a subtask in the form of text and visualizations.<br>Quality: Report comprises all relevant knowledge concepts in the form of text and meaningful visualizations. | BucketBriefing (clarify): For each breakout group a shared writing page for text and visualization.<br>a) Explain that learners are to work on the shared writing page.<br>b) Explain to learners quality criteria to report the solution.<br>c) Explain that discussion of exemplary solutions after the remaining time within the plenary group takes place. |

### 4.2.2 Critical-Thinking Pattern (CTP)

The *group goal* of the CTP is that learners simultaneously and collaboratively correct and improve an existing solution from a subtask within two hours. The collaboration helps them to achieve HLL effects in the discipline of critical thinking as well as teamwork and communication abilities. Typically, abstract solutions of HLL knowledge look professional, complex and thus, seem to be correct. Hence, the *group product* is an improved solution comprising text and visualizations for each subtask. This leads to subtasks that constitute sample solutions that challenge the learners in a way that HLL on the upper levels of Bloom's taxonomy (analyze, evaluate, create) will be addressed. The CTP comprises three distinct steps, each using a thinkLet to structure *group activities* to improve an existing solution. While the learners work within a subgroup in step 1, they collaborate in step 2 and rate their results individually in step 3. In step 1, each learner receives access to the existing solutions of all subtasks. On their own, each learner analyzes all provided solutions, marks mistakes, and makes notes for improvements. In step 2, learners are assigned to breakout groups. Each receives a subtask solution with a list of marked mistakes and improvements. Within breakout groups learners evaluate, interpret, and explain the solutions. They clarify improvement suggestions and write down a revised solution in the form of text and visualizations. A member of each breakout group presents the revised solution to the subgroup. In step 3, learners evaluate on their own whether the solutions of the subtasks are correct and whether they are satisfied with it. The *tool* support in steps 1 to 3 provides similar collaborative working spaces as the PSP with shared writing pages. Here, learners can mark mistakes (step 1), create a revised solution (step 2), and rate the revised solutions (step 3). After each step the tools generate a report of the current deliverables of the step (e.g. list of mistakes). The *group behavior* is restricted toward a focused collaboration like in the PSP. Table 4 illustrates the CTP and serves as moderation plan.

**Table 4.** Critical-Thinking Pattern (CTP): Overview and Moderation Plan

| | | | |
|---|---|---|---|
| **Learning objective** | Analyze, evaluate, and create. | **Task specification** | Content, context, connection, appeal to learners. Subtasks are exemplary solutions with mistakes. |
| **Individual goal** | Training HLL in the discipline of critical thinking, and teamwork and, communication abilities. | | |
| **Group product** | Correct and abstract solution in the form of text and/or visualization. | | |
| **Group changes** | 1: subgroup to breakout group | | |
| **Tool support** | GSS – separate groups, text editing, visualizations, voting: e.g., ThinkTank, GoogleDocs; flip charts, post-its, cards | | |
| | **Group activity & general description** | **Group product & quality indicator** | **Group procedures (thinkLet, PoC) [8]** |
| **Step 1: 30 min** | Subgroup:<br>Presentation of the solution of all subtasks and identification of mistakes and inconsistencies. | Product: Per subgroup, a list with identified mistakes and suggestions for improvements for each subtask.<br>Quality: Each mistake comprises a constructive suggestion for improvement. | BucketWalk (evaluate): For each subgroup a bundle of shared writing pages, each with a subtask solution.<br>a) Learners read and walk through the subtask solutions.<br>b) Learners mark aspects that are: false/not relevant, redundant/inconsistent, poorly formulated.<br>c) Learners write down suggestions for improvements (e.g., better formulation, correct knowledge concepts). |
| **Step 2: 80 min** | Breakout group & subgroup:<br>Correction of mistakes and inconsistencies. Finalization of correct solution and its presentation. | Product: Per breakout group, revised mistakes and inconsistencies of the solution.<br>Quality: Revised solution comprises all relevant knowledge concepts in form of text and meaningful visualizations. | BucketBriefing (clarify) : For each breakout group a shared writing page for a subtask.<br>a) Learners discuss and clarify marked mistakes and improvement suggestions.<br>b) Learners write down a revised solution for their subtask.<br>c) A member of each breakout group presents revised solution in front of the subgroup (max. 5 min). |
| **Step 3: 10 min** | Breakout group:<br>Assessment of the final solution by learners. | Product: Per breakout group, a rated solution of every subtask.<br>Quality: Positive values for correctness and satisfaction with the revised solutions. | MultiCriteria (evaluate): For each breakout group a shared voting page, each for a subtask.<br>a) Post a list of evaluation criteria (level of correctness, level of sophistication, satisfaction with revised solution) for each subtask solution.<br>b) Learners rate each subtask solution on a scale from 1[very bad] to 7 [very good]. |

# 5 Evaluation of Collaborative-Learning-Pattern Approach

## 5.1 Research Method

*Data Collection and Measures:* We started in 2014 and iteratively designed and evaluated the CLPA using a mixed method approach in line with collaboration engineering to evaluate our design goals [31] (Table 5). We raised explorative findings with real stakeholders and based the evaluation on qualitative and quantitative data [32] that comprised simulations [requirement-based evaluation and identification of stumbling blocks], walk-throughs [interview for stumbling blocks in the process design] by lecturers, and pilot-tests [survey, pre/post knowledge test] by learners (see Table 5). Based on established scales, measures were adapted from Petter et al. 2010 (*plausible; effective; feasible; predictive; reliable*) [9] to build the category system for a content analysis to analyze the qualitative data; and from Briggs et al. 2013 (5-item scales – *satisfaction with process [SP]; satisfaction with outcome [SO]; tool difficulty [TOOLDIF]; process difficulty [PROCDIF]*) [8]. Moreover, we used a pre/post knowledge test, each comprising five single-choice questions to investigate findings for knowledge increases among the learners for each treatment.

**Table 5.** Mixed-Method Approach to Evaluate the CLPA

| | **Iterative evaluations** | **1st** | **2nd** | **3rd** |
|---|---|---|---|---|
| **Qual. data** | Simulation [requirement-based evaluation] (by designer) | N = 1 | N = 1 | N = 1 |
| | Walk-through [interview] (by lecturers) | - | N = 4 | N = 2 |
| **Quant. data** | Pilot-test [survey, pre/post knowledge test (by learners) | - | - | N = 36 |

*Context and background of the study / participants:* All independent lecturers participating in the study teach information systems courses at master levels. The pilot tests were conducted in the same master's course on the topic of "Collaboration Procedures" and thus, with the same tasks. The participants were students from German and Swiss universities. In each semester the course was usually attended by 10 to 20 students. Among all pilot-tests a total of N = 36 students [17 males, 19 females], aged 22 to 34 years [mw = 26 years], participated in the CLPA. The CLPA with IT-supported tools (ThinkTank) and paper-based tools (flip chart, cards) was conducted by us as designers and by two lecturers, leading to four subgroups, each representing a treatment (Figure 2). *Procedures:* Before the evaluation in the field, the quality of the CLPA was assessed using a requirement-based evaluation by us as designers to investigate whether the design of CLPA meets the generalizable requirements. During the walk-through, the design of the CLPA was presented to lecturers and they were asked to identify inconsistencies. Participating in the pilot-test was voluntary and served as preparation for the final exam of the course. The two patterns were bundled, which created a 5-hour learning experience. Learners of a subgroup received a problem situation with four subtasks that required them to describe a blueprint of effective collaboration in the form of a storyline with scenes; each scene had to be described in an abstract and sophisticated way using text and visualizations to demonstrate knowledge concepts. The four subtasks constituted several sequences of scenes. First, learners completed a pre knowledge test, then passed the PSP and CLT, and finally completed a post knowledge test and a survey.

| | | CLPA experience | |
|---|---|---|---|
| | | paper-based tools | IT-supported tools |
| Moder-ation | Designer | Treatment 1: [group A] | Treatment 2: [group B] |
| | Lecturer | Treatment 3: [group C] | Treatment 4: [group D] |

| Period of Pilot-Tests for Conducting the CLPA in the field | | |
|---|---|---|
| Master course '14 | Master course '15 | Master course '16 |
| group A | group B | groups C & D |

**Figure 2.** Treatments in the Pilot-Tests

## 5.2 Results

*Simulation by designers and walk-throughs with lecturers.* We used a content analysis based on Kohlbacher 2006 [32] and grounded a category system on measures for pattern evaluation based on Petter et al. 2010 [9] (Table 5). *1st evaluation:* Plausibility, effectivity, and feasibility were examined by a simulation. There were no inconsistencies. To judge whether the CLPA is predictive or reliable was not possible. *2nd evaluation:* Walk-throughs with lecturers resulted in statements such as *"when do the learners work in groups and when do they work alone"*. We refined the comprehensiveness of instructions for the lecturer and the subtask wording for learners to improve effectivity. We also refined the grouping structure to improve instructions and rewrote its wording. With regard to the question whether the CLPA is predictive and reliable, the lecturers felt comfortable and were sure that *"the activities will work and the learners will be motivated"*. *3rd evaluation*: A lecturer stated his*"[…] feeling of being a coach"*. The discussion with each lecturer was, inter alia, about whether the process design of CLPA was effective and whether it was reliable. With the help of statements like *"[…] whether the time of that activity is realistic,* *depends upon the number of subtasks […]"* or *"how does that subsolution serve as relevant input for the next subtask; what are input-output relations between the subtasks?"* we improved the time and the sequence of activities, and thus the granularity of activities. We bundled activities to blocks and adapted validated thinkLets from CE. Moreover, the requirement-based evaluation was in line with Hevner 2004 and 2007 [11, 33], and indicated that the process designs of CLPA met the generalizable requirements and thus, coped with the demands of the environment and the body of CL literature. *Pilot-Tests with learners* helped examine whether CLPA met the design goals. We derived three hypotheses, each with exploratory research questions that guided our data analysis:

*$H_{1:}$ The CLPA conducted by the designer results in high learner satisfaction.*

- $Q_{1a:}$ Did CLPA with paper-based tools result in high learner satisfaction (T1)?
- $Q_{1b:}$ Did CLPA with IT-supported tools result in high learner satisfaction (T2)?

*$H_{2:}$ Lecturers are able to conduct the CLPA as good as the designer of the CLPA, so that learners are equally satisfied regardless of the moderator.*

- $Q_{2a:}$ Did conduction of CLPA by different moderators and with the same paper-based tools result in similar learner satisfaction comparing treatment 1 and 3?
- $Q_{2b:}$ Did conduction of CLPA by different moderators and with the same IT-supported tools result in similar learner satisfaction comparing treatment 2 and 4?

*$H_{3:}$ The conduction of the CLPA with different tool support leads to comparable scores of perceived satisfaction by the learners.*

- $Q_{3a:}$ Did conduction of the CLPA by the designer and with different tool support lead to a difference in learner satisfaction in treatment 1 and 2?
- $Q_{3b:}$ Did conduction of the CLPA by lecturers and with different tool support lead to a difference in learner satisfaction in treatment 3 and 4?

To make sure that groups started with no bias with regard to group size, gender, and age, we ran a Kruskal-Wallis test. The results showed no significant difference. To investigate findings for design goal 1 with regard to knowledge increases we compared the means of pre/post-knowledge tests in all treatments. There was a significant difference in the knowledge test performance in each treatment. Learners performed better in the post knowledge test (mean = 3.6) than in the pre knowledge test (mean = 3.0) (Table 6). To verify whether the construct scores have a better mean than a test score (neutral average score on 7-point Likert scale) we run a 1-sided t-test [34] to examine H1. The analysis of Q1a and Q1b showed that all constructs differed significantly, except in terms of TOOLDF for Q1b. Means were better than the average test score and thus on average and upper levels of the 7-point Likert scale (Table 7). To analyse $H_2$ and $H_3$, we run a Mann-Whitney test. The results indicate that learners rated the satisfaction in all treatments on upper levels. To investigate $H_2$, we analysed whether the CLPA can be conducted by different moderators (designer vs. lecturer). $Q_{2a}$ focused on the paper-based tool conduction of the CLPA by different moderators. We compared the means from treatment 1 and 3. There is no significant difference in the means of SP, SO, and PROCDIF. However, for TOOLDIF ($p<0.000$)

learners in treatment 1 (mean = 6.138) scored significantly higher than learners in treatment 3 (mean = 4.100). $Q_{2b}$ focused on the IT-supported CLPA conduction by different moderators. Thus, we compared the means from treatment 2 and 4. There is no significant difference in the means of SP, SO, TOOLDIF, and PROCDIF. To investigate $H_3$, we analysed whether the CLPA can be conducted with different tool support (paper-based tools vs. IT-supported). $Q_{3a}$ focused on the CLPA conduction by a designer with different tool support. A comparison of the means from treatment 1 and 2 showed no significant difference for SP, SO, and PROCDIF. However, for TOOLDIF there was a significant difference by treatment ($p<0.000$). Learners in the paper-based treatment 1 (mean = 6.138) scored significantly higher than learners in IT-supported treatment 2 (mean = 4.089). $Q_{3b}$ focused on the conduction with different tool support by lecturers. There is no significant difference for SP, TOOLDIF, and PROCDIF when comparing the means from treatment 3 and 4. But learners in the paper-based treatment 3 (mean = 5.640) scored significantly higher than learners in the IT-supported treatment (mean = 6.514).

**Table 6.** Subgroup Structure: Manipulation Check and Knowledge Increases

| | N | gender male | gender female | age | pre-test knowledge | post-test knowledge | p-value (2-tailed) |
|---|---|---|---|---|---|---|---|
| all groups | 36 | 17 | 19 | 26 | 3 | 3,6 | 0.000** |
| group A | 8 | 5 | 3 | 28 | 3,1 | 3,6 | 0.033* |
| group B | 10 | 7 | 3 | 26 | 2,9 | 3,7 | 0.003** |
| group C | 11 | 5 | 6 | 25 | 2,9 | 3,5 | 0.011** |
| group D | 7 | 0 | 7 | 25 | 2,7 | 3,5 | 0.045* |
| p-value (2-tailed) | 1.000 ns | 0.031 * | | 0.175 ns | 0.321 ns | 0.846 ns | - |

*Note:* Kruskal-Wallis test; mean difference significant **p< 0.01, *p < 0.05, ns = not significant; knowledge test (5-item scale)

**Table 7.** Evaluation Results: Means, Differences in Satisfaction

| | Treatment 1 (DP) group A | | Treatment 2 (DI) group B | | Treatment 3 (LP) group C | | Treatment 4 (LI) group D | | $Q_{1a}$ T1 | $Q_{1b}$ T2 | $Q_{2a}$ T1 vs. T3 | $Q_{2b}$ T2 vs. T4 | $Q_{3a}$ T1 vs. T2 | $Q_{3b}$ T3 vs. T4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | Mean (SD) | N | Mean (SD) | N | Mean (SD) | N | Mean (SD) | t-value (1-tailed) | t-value (1-tailed) | t-value (2-tailed) | t-value (2-tailed) | t-value (2-tailed) | t-value (2-tailed) |
| SP | 8 | 5.988 (0.66) | 9 | 5.822 (0.86) | 10 | 5.940 (0.74) | 7 | 6.029 (0.51) | 0.000 ** | 0.000 ** | 0.929 ns | 0.470 ns | 0.606 ns | 0.669 ns |
| SO | 8 | 6.025 (0.68) | 9 | 5.533 (1.24) | 10 | 5.640 (0.76) | 7 | 6.514 (0.50) | 0.000 ** | 0.003 ** | 0.474 ns | 0.055 ns | 0.606 ns | 0.025 * |
| TOOLDIF | 8 | 6.138 (0.71) | 9 | 4.089 (0.76) | 10 | 4.100 (0.54) | 7 | 3.714 (0.45) | 0.000 ** | 0.368 ns | 0.000 ** | 0.174 ns | 0.000 ** | 0.133 ns |
| PROCDIF | 8 | 5.163 (0.91) | 9 | 5.756 (0.59) | 10 | 5.680 (0.61) | 7 | 5.486 (0.28) | 0.005 ** | 0.000 ** | 0.081 ns | 0.210 ns | 0.093 ns | 0.536 ns |

*Note:* Mann-Whitney test; 7-point Likert scale (1= very less; 7 = very high); mean difference significant **p< 0.01, *p < 0.05, ns = not significant

## 6 Discussion

In the following, we discuss the results with respect to the two design goals defined at the outset of this paper. *DG 1 – help lecturers to conduct CL activities for HLL in the classroom:* Results from the qualitative content analysis provided insights on how to improve the design of the CLPA. Two lecturers conducted CLPA during several pilot schemes and achieved comparable results (increases in knowledge test performance; satisfaction measures) with the learners compared to the conduction by the designer. The results regarding $H_2$ with $Q_{2a}$ and $Q_{2b}$ showed no significant difference in the scores; except for TOOLDIF in $Q_{2a}$. The difference in the TOOLDIF may indicate that use of paper-based tool support should be described in more detail. The results show that lecturers become empowered to conduct CLPA and that the CLPA has the potential to enable knowledge increase among learners. *DG 2 – help learners to proceed through CL activities for HLL:* Among all treatments the satisfaction scores were above an average score of 4 and thus, on average and upper levels of the 7-point Likert scale ($H_1$). This indicates that learners are able to follow the CL activities in a positive manner. $H_3$ focused on whether there is a difference in the conduction of CLPA with paper-based tools and IT-supported tools and thus, which way of tool support is easier for learners to follow. To avoid bias by moderator we compared treatments 1 and 2 (both moderated by the designer) to gain insights for $Q_{3a}$; and treatments 3 and 4 (both moderated by a lecturer) to gain insights for $Q_{3b}$. $Q_{3a}$ showed a significant difference in the measures of TOOLDIF ($p<0.000$). Learners felt more comfortable with paper-based tool support, since they may have perceived the collaboration as being closer. Another explanation could be that they perceived visualizing or editing contributions as a more flexible way, and thus felt more comfortable with it. However, comparing lecturer moderated treatment 3 and 4 results showed no significant difference in TOOLDIF. Thus, the difference in treatment 1 and 2 may be attributed to the facilitation skills of the designer who moderated the CLPA experience. A similar conclusion can be drawn with regard to $Q_{3b}$ for SO ($p<0.025$). Learners in IT-supported treatment 4 are more satisfied with the outcome than learners in paper-based treatment 3. Thus, the SO with IT-supported tools seems to be more satisfying. However, when comparing treatment 1 and 2, there is no significant difference in means of SO. An explanation for the significant difference of SO in treatment 3 and 4 may be attributed to the facilitation skills of the lecturer.

## 7 Limitations, Future Research, Contribution, and Conclusion

This study is not without limitations, which provide future research opportunities. First, the evaluation of CLPA was communicated as a HLL experience. For that reason we built exemplary instances that bundled the PSP and the CTP. Consequently, learners followed a HLL experience in which they passed the PSP and then the CTP. It would be valuable for future research to evaluate each pattern on its own. Second, in total we have N = 36 learners that participated in the CLPA (four subgroups). To strengthen our results, it would be valuable for future research to evaluate the CLPA with more groups in a large-scale lecture. Thirdly, the design goals of this study referred to enhancing lecturers to conduct CL activities for HLL and to providing learners guidance to proceed through these activities. The focus was not on evaluating learning success. Hence, future research should investigate knowledge increases among learners in more detail – e.g. group deliverable evaluations by independent lecturers. In particular, follow-up evaluation will need to assess critical thinking and problem-solving skills in more detail. The contributions of the study are positioned along the components of DSR: The purpose and scope of the CLPA is to package sufficient collaboration expertise to conduct CL activities for HLL. To address this set of unsolved problems we provide principles of form and function inherent in generalizable requirements and the CLPA design with its two patterns. This provides guidelines to enable CL activities for HLL in the classroom.

We outlined the CLPA as an approach that helps lecturers to leverage the power of HLL in the disciplines of problem-solving and critical thinking. We based our research on justificatory knowledge from CL and collaboration engineering, and thus, postulate CLPA's potential for enhancing HLL. With three design and evaluation cycles we build expository instantiations of CLPA and evaluated it with real stakeholders by using a mixed methods approach. The results provide insights for CL literature since they show that principles from CE literature can be applied to the field of learning in a way that process restrictions have the potential to support learners in their HLL experience. With the CLPA design we provide insights on how to design CL activities that package sufficient collaboration expertise to empower lecturers to conduct those activities in a predictive way and provide learners guidance to cope with open-ended HLL tasks. Scalability of CLPA is given when several subgroups (with breakout groups) work simultaneously, since CL activities take place there. The CLPA provides prescriptive knowledge and resembles a *'theory of design and action'* [13] of the contribution type *'improvement'* [12].

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