Evaluation of a Pattern-Based Approach for Business Process Improvement

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Abstract. Although many approaches for business process improvement (BPI) are available and have proven their usefulness, it is often stated that they do not provide sufficient methodological support for all phases of a BPI initiative. To close this gap, a pattern-based approach has been suggested as a suitable means to directly support the "act of improvement" and to provide systematic guidance. However, what is missing is an evaluation that provides well-founded insights into the qualities and benefits of this approach. Therefore, this paper presents the results of a laboratory experiment which was conducted to assess the impact of the BPI-Pattern Approach on a process improvement project. The findings, which are based on a number of hypothesis tests, confirm a positive influence on both effectiveness and efficiency when the BPI-Pattern Approach is used.

Keywords: Business Process Improvement, BPI Pattern, Evaluation, Laboratory Experiment

1 Introduction

Business process improvement (BPI) together with its related methods and techniques remains an important topic in research as well as for practitioners. Among the major drivers prompting companies and other organizations to change their processes are cost savings and increased productivity as well as the need to improve products, customer satisfaction or organizational responsiveness to stay competitive [1].

As a result, there is a plethora of different approaches supporting the improvement or redesign of business processes, e.g., *BPI* according to Harrington [2], *Business Process Reengineering (BPR)* [3], or *Six Sigma* [4], to name but a few well-known examples. Existing approaches provide extensive methodological support for e.g., mapping processes, identifying problems and their root causes, etc. However, when it comes to the actual improvement, i.e., the transformation of a process from its "as-is" to a desired "to-be" state, they often rely on creativity, personal skills and experience for the development of an enhanced process design [5], [6]. This pivotal phase of BPI, the so-called "act of improvement", lacks systematic methodological support [7] as tangible instructions on how to achieve substantial improvements are missing [8]. To address this problem, a BPI-Pattern Approach was suggested that systematically

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supports the "act of improvement" in BPI initiatives [9], [10]. Its core components are a catalog of BPI-Patterns, which convey proven knowledge and instructions of how to achieve process improvements, together with a selection process to guide the identification and selection of appropriate patterns for a given situation. This approach was developed following the design science paradigm [11], [12] and its applicability was already demonstrated by a case study [10]. However, what is missing is an in-depth evaluation of the usefulness and advantageousness of the new pattern-based approach in comparison to conventional practices. Therefore, the paper at hand describes a laboratory experiment, which was conducted to quantitatively evaluate the effectiveness as well as the efficiency of the BPI-Pattern Approach. The results gained from the experiment allow for a better assessment of the potential benefits of using BPI-Patterns for process improvement in practical settings.

The remainder of this paper is organized as follows. Section 2 covers conceptual basics of BPI, the BPI-Pattern Approach, and the evaluation phase in design science research. Section 3 introduces the research model including our hypotheses and describes the design, materials and implementation of the experiment. The results are presented in section 4 and their implications discussed in section 5. Section 6 provides a short summary of the findings and an outlook on further research.

2 Conceptual Basics

2.1 Business Process Improvement (BPI)

The improvement of business processes has become a core task in many organizations and is an integral part of the business process lifecycle [13]. Its overall aim is to make processes more effective, efficient and flexible [2], e.g., by reducing costs or cycle times, and thus to yield competitive advantage. Process improvement is considered as essential for creating sustainable value for customers or innovating products and services [14], and organizations link the improvement of their processes to their business strategies [15]. Existing approaches for process improvement are manifold (see e.g. [2-4], [16]) and have proved their usefulness.

However, it appears that none of them adequately supports the user through all the stages in an improvement project, especially when it comes to the "act of improvement" [7]. This very phase is at the heart of any BPI project where the transformation of a process from its "as-is" state to a desired "to-be" state takes place. Actual instructions on how to improve a process in respect of given objectives (e.g. reduce costs, shorten cycle time, etc.) are very scarce and generic [8], and thus many improvement approaches rely on human creativity and personal experience [17]. Even though one "brilliant idea" can bring about significant improvement, its occurrence is always uncertain and often depends on the know-how of individual key players. The development of substantial improvements remains a major challenge in BPI projects and lacks sufficient methodological guidance [7], [18]. To better support BPI performers, structured methods and techniques are required [19] as well as guidelines describing the necessary changes that have to take place [20]. The use of a pattern-based approach for BPI is one possible solution that meets those requirements.

2.2 BPI-Pattern Approach

The concept of patterns is widely used in IS (e.g., design patterns in software development [21], workflow patterns [22], etc.). In the field of BPI there are several works that address the topic of how patterns can be utilized for the improvement of business processes. One group focuses on the collection and description of generic improvement measures (cf. [23-25]). A second group deals with the question of how to run or organize improvement projects (cf. [26], [27]). Because of their inherent characteristics, the use of patterns is also a promising approach for supporting the "act of improvement". Patterns are suited to precisely describe a working solution for a problem in a specific context [21], which is based on proven knowledge [28], but, at the same time, they are generic enough to be reused in many similar cases [29]. Thus, so-called BPI-Patterns guide through the application of an improvement action and help to overcome the shortcomings of existing BPI approaches as mentioned above.

A BPI-Pattern Approach supporting the "act of improvement" is suggested by Falk et al. [9], [10]. It consists of two main components that are both integrated in a software tool: a *pattern catalog* as a repository of improvement propositions and a step-by-step *selection process* for identifying and selecting suitable patterns. The patterns themselves are derived from BPI literature, case studies or experience from real-life projects [30]. In addition, their applicability and effects have been substantiated by means of a simulation [31]. A standardized template comprising the attributes as defined by the underlying data model [9] ensures a consistent description. Its core attributes reflect the definition of a BPI-Pattern as a reusable *solution* for a certain *problem* in a business process within a certain *context* [9] and comprise instructions on how to change the process' elements (e.g., activities, resources, control-flow, etc.) to transform it from its non-satisfactory "as-is" to a desired "to-be" state. The application of a BPI-Pattern has an *effect* (positive, neutral, negative) on the performance dimensions (cost, time, quality, flexibility). An example of a BPI-Pattern that has a positive effect on cycle time is "Parallelize Activities" where formerly sequentially ordered activities are performed simultaneously. The software tool not only allows for the management of the pattern catalog but also guides the user through the selection process. There are two alternative starting points depending on whether the BPI project is targeted at predefined objectives that should be achieved or driven by problems that are detected in the processes. By matching the effects of the patterns with the goals of the improvement project, only those patterns that show the desired outcome are regarded further. Based on the identification of problems together with a root cause analysis, patterns solving or at least mitigating those particular problems are filtered. Either way, both possibilities require the execution of both steps, i.e. if patterns are first to be selected according to their effects, the next step is to look at the problems and vice versa. Afterwards, the contexts of the patterns are checked against the environmental conditions in the case at hand to make sure that they are applicable in the given situation. Finally, the remaining patterns that are candidates for implementation are prioritized, and a decision has to be made by the user which pattern(s) will be applied in the end. That way, the BPI-Pattern Approach provides a systematic, tool-assisted means to support the "act of improvement".

2.3 Evaluation in Design Science Research

Design science research (DSR) is characterized by the creation of artefacts for a specific purpose that solve practice-oriented problems [11], [32]. The evaluation of those artefacts is an integral part of the DSR methodology [12] and considered vitally important to prove the usefulness of the developed artefacts [33]. To perform an evaluation, a number of strategies making use of various evaluation methods (e.g. interviews, simulation, experiments) have been suggested [34-36]. Experiments as a method are particularly suited for a systematic assessment of an artefact's qualities [37]. For the evaluation of the BPI-Pattern Approach, a laboratory experiment was preferred to other evaluation methods because of the following reasons: In a laboratory environment, confounding variables can be better controlled or be eliminated [38]. In contrast to case studies, e.g. the participants are more homogenous and can be assigned to the groups randomly, the "as-is" process to be enhanced as well as the provided information are exactly the same, etc. In addition, a laboratory experiment shows a relatively high internal validity, which allows to determine if changes of the dependent variables (e.g. improvement effectiveness) result from changes of the independent variables (e.g. use of pattern-based approach) or not [39].

3 Evaluation of the BPI-Pattern Approach by an Experiment

For the evaluation of the BPI-Pattern Approach (see section 2.2) and to answer the question regarding its utility a laboratory experiment is conducted (cf. [37-39]). The focus of the study is on both the effectiveness and efficiency when seeking to improve existing "as-is" business processes. For that purpose, the experiment builds on a comparison of two groups: one group uses the BPI-Pattern Approach to identify potentials for improvement and generate process changes in a guided and structured way whereas the second group (control group) works without a systematic approach but is free in using creativity and innovative ideas to enhance the process (one factor with two treatments). As a general principle a completely randomized design was chosen where the subjects are randomly assigned to the groups. The setup of the laboratory experiment is explained in detail in the following section.

3.1 Experimental Design

Our research model (see Figure 1) is based on the underlying assumption that the use of a systematic improvement approach, such as BPI-Patterns, leads to better results (e.g., cost or cycle time reductions) [20], [25], and reduces the overall effort of identifying such improvement possibilities and developing the new "to-be" process design (i.e. time savings in process improvement projects) [23]. The quality of the results increases when tried and tested patterns are used, a concept which is already successfully used in other fields (e.g. software development) [21]. It seems reasonable that this is equally valid in the context of BPI and experiences so far are promising [23], [24]. Based on these assumptions, the following pairs of hypotheses (see Table 1) can be stated which are to be tested by means of the laboratory experiment.

Table 1. Hypotheses on the effects of the BPI-Pattern Approach

Improvement Effectiveness:	
H_0a:	The use of the BPI-Pattern Approach does not generate better improvement solutions than relying on creativity skills.
H_1a:	The use of the BPI-Pattern Approach does generate better improvement solutions than relying on creativity skills.
Expenditure of time:	
H_0b:	The use of the BPI-Pattern Approach does not reduce the time needed to identify improvement potential and to develop an enhanced "to-be" process design.
H_1b:	The use of the BPI-Pattern Approach does reduce the time needed to identify improvement potential and to develop an enhanced "to-be" process design.
Improvement Efficiency:	
H_0c:	The use of the BPI-Pattern Approach does not increase the time efficiency when developing an improved process design.
H_1c:	The use of the BPI-Pattern Approach does increase the time efficiency when developing an improved process design.

All elements of the research model have to be operationalized for the purpose of the actual experiment at hand. It is based on a single binary, independent variable, which is whether a participant is supported by the BPI-Pattern Approach or not. The dependent variables are 1) *Improvement Effectiveness*, 2) *Expenditure of Time*, and 3) *Improvement Efficiency*. *Improvement Effectiveness* is defined by the extent to that the "as-is" process has been improved; i.e. the process performance of the newly developed "to-be" process exceeds the level of the "as-is" process. For complexity reasons this variable has been narrowed down to the dimension time and considers reductions in the average total processing time per process run (in percent). The instrument used for measuring are the adapted "to-be" process models, handed in by the participants. Total processing time is calculated by adding up the processing times of all process activities applying the probability of execution of the respective process path for weighting. *Expenditure of Time* quantifies how much time (in minutes) is needed to complete the "act of improvement", i.e. the very phase where improvement potential is identified and an enhanced process design is developed. The participants are guided by a road map and have to fill in the precise time when they start or finish a specific task. Finally, the variable *Improvement Efficiency* expresses how much improvement could be achieved per time unit and is calculated as achieved process improvements relative to the time needed for their development.

In addition, the research model covers the following factors which have a possible influence on the outcome: *Methodological Knowledge*, *Domain Knowledge*, *BPI Experience*, *Process Understanding*, and *Problem Detection*. To largely eliminate the influence of those factors, we deliberately chose students taking a particular course in process modelling as subjects. Hence, they have a similar background regarding their theoretical and practical skills in process modelling, analysis and improvement which helps to keep the confounding factors stable. Since the focus of the experiment is on evaluating the effect of the BPI-Pattern Approach alone, it is hereby prevented that the participants' diverging personal experience gain too much influence on the experiment results. The aforementioned factors are measured using a set of questions within a questionnaire. The variables *Methodological Knowledge*, *Domain Knowledge*, and *BPI Experience* are covered by a number of questions (e.g., „How often do you deal with BPI?"), each of them having a four-item, ordinal scale with point values assigned. To gather information on *Process Understanding*, open questions as well as true/false questions about different facts in the "as-is" process are used. To determine the degree of *Problem Detection*, the participants had to fill in a free text field to answer the question "What problems could you identify in the 'as-is' process that may cause long processing times?". The value for this variable is calculated as the portion of problems identified by the participant in relation to all problems that are contained in the process model. Because those variables addressed by the questionnaire have a potential impact on the results of the experiment, it is important that they are controlled or at least made explicit so that they can be taken into account when analyzing and interpreting the results [38], [39].

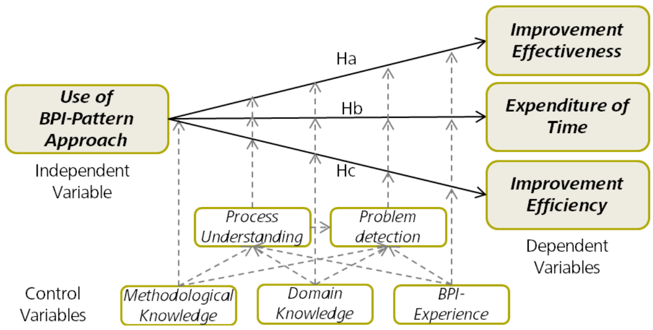

Figure 1. Research model

3.2 Implementation

The experiment was conducted in form of a fictional BPI project working on the matriculation process of a German university that has been slightly adapted for the purpose of the experiment. It has to fulfil certain criteria such as being representative of a practical and realistic BPI case, being sufficiently complex to be resistant to overly obvious or trivial enhancements, but at the same time remaining manageable within the scope of a laboratory experiment. The predefined goal of the project was to alter the given matriculation process such that its processing time is reduced as far as possible but the process still fulfils its core tasks as requested. The participants in the experiment, undergraduate students attending a bachelor's degree course in business process modelling, were randomly assigned to one of two groups: group A used the BPI-Pattern Approach to support the "act of improvement" whereas group B worked without BPI-Patterns. Because the same process model was used for all tests due to comparability reasons, the assignment to the groups was strictly alternative. Otherwise, learning effects while working on the process with one method would have corrupted the results when the second method was used afterwards. In total, 47 students participated in the experiment, 23 in group A and 24 in group B, thus leading to a balanced design with equal group size.

The participants in Group A, who worked with the BPI-Pattern Approach, used a prototypical tool that supports the management of the pattern catalog and especially the selection process of applicable BPI patterns based on certain criteria, such as desired effects, problems to be solved, or contextual requirements (cf. section 2.2). For the purpose and scope of the laboratory experiment the tool was populated with a catalog of 12 different BPI-Patterns. Beyond that, all participants were provided with the same materials: information about the project goals and the measurement of the performance indicator processing time, a textual description of the "as-is" process together with some fixed requirements that cannot be changed, and transcribed excerpts of interviews with the process owner and employees. Furthermore, a process model in eEPC notation was provided both as a paper-based and as a processable electronic version in ARIS Business Architect. The chosen process consisted of 41 process steps and contained several decision points, branches and loops (24 AND/XOR connectors) to express an adequate level of complexity. The process model, besides the graphical representation of the process flow, contained in particular information about the processing time (in minutes) of each activity and the probability values attached to decisions (XOR connectors) during the process operation. In addition, details about the organizational units involved, the requested or created documents, and the required data were provided. The participants' task was to improve the provided "as-is" process model using the ARIS business architect, by either using the BPI-Pattern Approach or relying on brainstorming and individual creativity skills. There were four major improvement possibilities (e.g. eliminating redundant tasks, re-arranging existing activities in a more logical order, etc.) being supposed to be identified by the participants. Improvement suggestions beyond that, regardless of whether made by group A or B, are also considered as long as they meet the requirements specified in the materials of the experiment. The created "to-be" process models together with the filled in questionnaires have been submitted to the researchers at the end of the experiment.

Guidelines on how to proceed in course of the experiment were provided on a form sheet which instructs the participants and lead them through the experiment step by step. In addition, the procedure was explained by the researchers to the participants before the actual experiment started. Thus, it was ensured that every participant clearly understood the course of action and followed the same standardized steps while working on the fictional process improvement project.

All materials used in the experiment had been pretested before by three fellow researchers as well as a test group of eight students whose state of knowledge compared to that of the actual participants. Both tests provided valuable feedback which was used to refine the concerned materials and/or instruments and confirmed that the provided information, questions and tasks are clear and understandable.

4 Results

Subsequent to the experiment, the 47 submitted "to-be" process models and the questionnaires were carefully examined by two researchers independently. In so doing, each process model was double-checked by a fellow researcher; first without knowing the results from one another to avoid any bias, afterwards, the results were compared against each other to settle different interpretations. Four of them had to be excluded because they were either incomplete, showed data inconsistencies, or allowed for diverging interpretations. Hence, 43 applicable results, 21 in group A and 22 in group B, remain for further analysis and are described in the following.

Table 2. Results of the experiment: values of the dependent variables

Variable	Group	N	Mean	Std. Deviation	Std. Mean Error
Improvement Effectiveness	A: with BPI-Patterns	21	.214467	.1114372	.0243176
	B: without BPI-Patterns	22	.142259	.1136285	.0242257
Expenditure of Time	A: with BPI-Patterns	21	27.05	8.680	1.894
	B: without BPI-Patterns	22	28.27	6.734	1.436
Improvement Efficiency	A: with BPI-Patterns	21	.00810481	.000913604	.000913604
	B: without BPI-Patterns	22	.00512436	.000940070	.000940070

Since we are interested in the effect of the BPI-Pattern Approach in isolation, it is an important question if the observed effects on the dependent variables result from changes of the independent variable or are otherwise attributable to external, confounding factors. Therefore, as a first step, we analyzed the values of the control variables for both groups. Altogether, the two groups in the experiment were quite homogeneous; both, the mean values and the distributions were almost identical. This is also the reason why no statistically significant correlation between any of the control variables and the dependent variables could be verified. A regression analysis based on models that contain the control variables only, shows no significant results (F-test with p-values between .078 and .673) and reveals that such models cannot provide a reliable explanation for the changes observed in the values of the independent variables. Including "Use of BPI-Pattern Approach" as an independent variable increased the model quality as explained further below. The model assumptions, e.g. Gauss-Markov theorem, are sufficiently satisfied; the residues are independent and approximately normally distributed. Based on the aforementioned points, we can fairly assume that the changes we observed, e.g., for effectiveness or efficiency, are referable to the BPI-Pattern Approach. Both foster a high internal validity of the experiment's results.

To evaluate the impact of the BPI-Pattern Approach on business improvement initiatives, the values for the variables of interest, namely Improvement Effectiveness, Expenditure of Time, and Improvement Efficiency, were measured. Hereafter, the mean values of both groups are compared to determine the effects of the BPI-Pattern Approach. Table 2 shows the values of the arithmetic mean, the standard deviation, and the standard error of the mean for groups A and B, respectively. To test our three hypotheses, which we posed at the beginning of section 3.1, a two-sample t-test was used. According to a Kolmogorov-Smirnov test, the variables are normally distributed for each group. The results of these hypothesis tests are shown in Table 3. In addition, a nonparametric Wilcoxon-Mann-Whitney test, which is more robust than the t-test, was conducted and shows the same results.

Table 3. Hypothesis test for Ha, Hb, and Hc

Variable	t-test for Equality of Means					95% Confidence Interval of Diff.	
	t	df	Sig.	Mean Diff.	Std. Err. Diff.	Lower	Upper
Improvement Effectiveness	2.103	41	.042	.0722076	.0343413	.0028540	.1415612
Expenditure of Time	-.518	41	.607	-1.225	2.363	-5.997	3.547
Improvement Efficiency	2.271	41	.028	.002980446	.001312497	.000329805	.005631087

Improvement Effectiveness is represented by the reductions in processing time comparing the new "to-be" process design with the original "as-is" process. The mean values for the degree of improvement are approx. 0.21 and 0.14 for group A and B, respectively, whereas the standard deviation shows similar values with group A lying slightly below group B. The results show a significant increase of the improvements that were achieved when the BPI-Pattern Approach was used during the experiment. The significance level is above 95% and the lower and upper bound of the 95% confidence interval show the same sign. This leads us to reject the null hypothesis H_0a and to support our assumption that the use of the BPI-Pattern Approach increases the improvement effectiveness, i.e. it generates better improvement results than by relying solely on e.g. creativity skills. The regression model including the independent variable as well as control and moderator variables is significant at p=.039, with "Use of BPI-Pattern Approach" having the strongest influence (p=.026 on "Improvement Effectiveness".

Regarding the second hypothesis, the use of the BPI-Pattern Approach would reduce the time that is needed to develop an enhanced "to-be" process design, the results are inconclusive. Based on the p-value of .607, the null hypothesis cannot be rejected. Moreover, the lower and upper bound of the confidence interval change signs. Therefore, no clear statement can be given about the influence of the BPI-Pattern Approach on the expenditure of time that is needed to improve a business process. However, the average time span needed for the "act of improvement" was slightly lower in group A than in group B (27.05 vs. 28.27 min) and the bigger part of the 95% confidence interval lies in a negative range. Moreover, the regression analysis regarding the variable "expenditure of time" resulted in a negative coefficient (β = -1.537) for "Use of BPI-Pattern Approach", indicating, even if not statistically significant, that possible time savings due to the use of patterns can still be assumed but are subject to further scrutiny.

Improvement Efficiency is addressed by the third hypothesis and expressed by the improvements achieved in relation to the time needed for their development. The observed results reveal a significant relationship between the use of the BPI-Pattern Approach and the variable improvement efficiency, which is on average 1.6 times higher for group A using the patterns (≈ 0.008) as compared to group B not using the patterns (≈ 0.005). Both the signs of the lower and the upper bound of the confidence interval are positive and, thus, confirm the direction we expected. Again based on a two-sample t-test, which reaches a significance level higher than 97%, we reject the null hypothesis H_0c and conclude that the use of the BPI-Pattern Approach increases the time efficiency when developing an improved process design, i.e. "more" improvement can be achieved per time unit. Moreover, the improvement efficiency is more reliable when patterns are used since the standard deviation in group A is lower than those in group B. The regression model for improvement efficiency is even highly significant (p=.004) whereby the two variables Use of BPI-Pattern Approach (p=.009) and Methodological Knowledge (p=.012) show a significant influence.

To get a deeper understanding of the results as well as to point out some implications related to the practical usefulness, they are discussed in more detail in the following section.

5 Discussion

The purpose of our laboratory experiment was to thoroughly evaluate a BPI-Pattern Approach in accordance with the DSR methodology and to determine its capabilities in supporting the "act of improvement" in a process improvement project. The overall results support the conclusion that the pattern-based approach possesses some advantages as all three dependent variables covered by the experiment tend towards the better values in case the BPI patterns are used (see Figure 2). The positive influence on two of them, namely improvement effectiveness and improvement efficiency, is statistically significant in addition. However, the effect size becomes more relevant at a practical level and can only be judged considering the particular characteristics of the business process which has to be improved. For example, a 1%-reduction in time or cost for a mass production process may result in a major impact whereas for other processes with just a few instances the changes have to be many times greater to be of practical relevance. In our case, the average difference in improvement effectiveness between the two groups equals approx. 61 man-days and, thus, has indeed a material impact. In addition, the business process that has to be improved may be an important factor which influences the performance of the BPI-Approach, e.g., based on its structure, complexity, or the type of problems that have to be solved.

The use of the BPI-Pattern Approach increases the improvement effectiveness, which was confirmed by the statistically significant results of the experiment. Taking a closer look at effectiveness, the use of patterns is no guarantee that significant improvements or any improvement at all can be achieved. In our experiment, we found cases where the processing time could not or barely be reduced in both groups even if the participants had applicable patterns at their disposition (see Figure 2(1)). In addition, the case showing the highest degree of improvement occurs in group B, without patterns. A possible explanation is that the BPI patterns primarily aim for incremental, evolutionary enhancements whereas the control group was free to develop more radical improvements, too. This effect could even strengthen when, unlike in the experimental setting used here, teams are assigned to develop the "to-be" process design. In this case, the group dynamics when creating improvement solutions will have some influence on creativity and thus on the improvement effectiveness.

However, what could be shown for the group which used the pattern-based approach is, that if a problem in the “as-is” design of the process was detected correctly, the probability that this problem was solved or at least partly addressed was much higher than in the control group working without patterns. This indicates that the BPI-Pattern Approach significantly increases the chances of finding and successfully implementing a solution, presumed such a one exists.

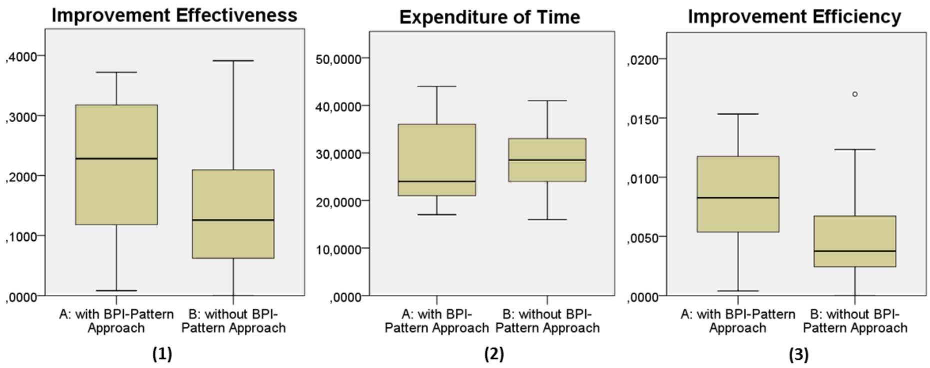

Figure 2. Box plot diagrams of the three dependent variables for group A and B

Even though the arithmetic mean (A: 27.05 min; B: 28.27 min) and the median (A: 24 min; B: 28.5 min) of the variable Expenditure of Time are slightly lower when the pattern-based approach is used, the effect is far weaker than anticipated and thus not statistically significant (see Figure 2(2)). In addition, not a single participant from group A (with patterns) passed through the “act of improvement” in less time than the fastest of group B (without patterns). Similarly, the maximum time in group A exceeds those in the control group. This indeed contradicts our initial expectations, but there are several explanations for these findings. On the one hand, the BPI-Pattern Approach was quite a new method the students were not trained on (participants had obtained a short introduction the week before the experiment started). Because of learning curve effects the results may change when the approach is used over and over. On the other hand, it is easily conceivable that participants who had no BPI-Patterns provided “gave up” if they could not find an adequate solution within a certain time interval. In contrast, the other group continued searching the pattern catalog for patterns that fit their needs.

It is often argued that structured guidelines and a formalized procedure, both provided by the BPI-Pattern Approach, would facilitate process improvement and make redesign projects more efficient [23], [24], [40]. This effect was also clearly detectable in the results of our experiment (see Figure 2(3)). The regression model explaining the dependent variable improvement efficiency shows a high significance which can be ascribed to the BPI-Pattern Approach and the degree of methodological knowledge of the user. What is different to the theoretical considerations in literature is that this is not mainly due to time savings but rather because of implementing more effective improvements. Another topic, discussed by researchers, is that a systematic improvement approach almost necessarily leads to some kind of improvement if only sufficient time and effort is invested [41]. This can be approved based on our observations as we found a significant positive correlation between time and improvement within group A (with BPI-Patterns), but not for the control group. The findings indicate that if one searches long enough some kind of improvement solution will be found, presumed the pattern catalog contains suitable patterns which fit the problem.

Business process improvement projects are often dominated by external advisors who play the role of method experts and contribute the methodological knowledge that is inevitable to successfully run such a project. However, it is recommended to better involve the concerned employees to exploit their domain-specific knowledge as well as to minimize the resistance to change which is a common phenomenon in many organizations [27]. Pattern-based approaches are seen as an instrument to especially support novices by providing step-by-step guidance and conveying expert knowledge they can build on. The data gathered during the experiment clearly classify the participating bachelor students as BPI novices showing relatively low values for Methodological Knowledge, Domain Knowledge, and BPI Experience. However, the overall results of our evaluation show that even such novices in BPI can achieve considerable improvements based on the BPI-Pattern Approach.

The findings of our research revealed insights into strengths and weaknesses of the analyzed approach, too. Examining the data gathered during the experiment we identified possibilities to further improve the BPI-Pattern Approach. First, a number of participants in group A correctly identified the relevant process performance problems but could not find the corresponding match in the pattern catalog. Thus, the problem selection process and the problem description template should be better aligned. Second, those patterns providing more than one example to explain their functional principle were rated to be easily comprehensible. Adding a reasonable number of examples (e.g. covering different application domains) would probably advance the identification and adoption of the patterns.

6 Conclusion

In this paper we present the findings of a laboratory experiment which was conducted to evaluate a BPI-Pattern Approach according to the principles of design science research. As a result, it could not only be demonstrated that the approach works in the particular setting provided in the experiment, i.e. the design science artefact fulfils its purpose as intended, but also that it supports the “act of improvement” better than other approaches. This statement is based on the test of three hypotheses, a regression analysis and further inspection of the experimental results. Two of our three assumptions are supported at a statistically significant level and the experiment confirmed that the BPI-Pattern Approach has a significant positive influence on both improvement effectiveness and efficiency. This makes the BPI-Pattern Approach a valuable asset when seeking for the improvement of existing business processes.

The contribution of this research is twofold and provides valuable insights for theory and practice. From a scientific point of view, it provides evidence that the newly developed artefact, the BPI-Pattern Approach, works as intended. We were able to confirm the common assumption that a more structured approach for BPI would generate better results (cf. [20], [24]) which could be explicitly demonstrated for the experimental scenario. Furthermore, the experiment helped to verify some of the qualities which are ascribed to patterns in general, such as providing guidance to novices [42] or reducing the effort of developing solutions [23], [24]. The contribution for practitioners is that the practical benefit of the BPI-Pattern Approach has been experimentally verified. Hence, it can be considered as a new instrument which expands the existing toolbox of methods, techniques and approaches that are used in improvement initiatives.

However, we still see some limitations which require further research regarding the evaluation of the BPI-Pattern Approach. There possibly exist other factors that have not been taken into consideration but may influence the effects of the pattern-based approach, and therefore should be part of future studies. These include but are not limited to e.g. usability aspects of the used software tool, the level and the complexity of the business process that has to be improved, the impact of group dynamics and teamwork etc. It would also be interesting to repeat the experiment with experienced BPI experts and to determine whether there are any differences regarding the approaches' benefits compared to our rather unexperienced user group. A long-term study could be used to validate if the advantages of the approach are stable over time or decrease e.g. because users have memorized the patterns and gained expertise.

The positive results of the evaluation refer to the particular setting which includes a number of simplifications due to the experimental design (e.g. number and size of the processes to be improved, number of available BPI-Patterns in the catalog etc.). Although the exemplary scenario was based on real-world data, the use of other evaluation methods, such as field experiments or case studies, which are able to capture the manifold interdependencies occurring in practice, is recommended to validate the findings in the context of real-world applications.

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