Systematically reusing low-code IT artefacts; A technological and managerial approach

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1. Introduction and Problem

Business Process Management (BPM) has advanced from "simple" projects to a sustained organisational effort [1,2]. Organisations build capabilities to continuously improve upon business processes and to automate them. Such continuous efforts can be conducted centrally or decentrally across the organisation [3,4]. RPA, for example, is a BPM technology, that also enables the decentralised development of automation in business processes. The participants in the processes thus independently design the flow and automation of these processes. They become Citizen Developers, 'regular' (non-IT) employees without much programming knowledge who can develop their own IT applications and thus digitise and automate processes.

In traditional digitalisation and automation, the reuse of artefacts has a long tradition (see e.g., 5,6). Some of the resulting concepts, such as frameworks, methods and objects, have been integrated into standard software development practices (see, e.g., 7,8). Reusing traditional IT artefacts can be especially valuable due to the high development cost and time required to create such artefacts. However, the reuse of such artefacts is not constrained to cost and time considerations: Other reasons are keeping high-quality reliable code instead of developing new, a lack of capable programmers and attempting to reduce maintenance needs overall [9,11–13].

The advent of low-code and citizen developer applications has enabled employees without in-depth programming knowledge to create their own applications [14]. Similarly, it enabled organisations to automate business processes in which automation would previously, not have been feasible due to the development cost faced or missing development capacity [11,15]. Like in regular IT-artefact development, arguments towards the reuse of such artefacts include; considerations of development effort (cost, time and available skilled workers) [16,17], quality and reduced long-term maintenance [18]. RPA bots for example, tend to break when the target-applications User Interface changes [19]. Schneider et al. [12] even name environmental reasons for reuse in computationally intensive applications.

Despite the importance of reuse and the abundance of concepts from the extensive tradition of IT artefact reuse, these concepts have not caught on in the same systematic way in low-code and citizen developer practices. Hence, research calls for concepts that aid reuse both in Business Process Automation (BPA) and also in Business Process Management (BPM) [17,20–22].

There seem to be three main issues that impair widespread reuse in low-code and citizen developer settings; *I1) The low cost of artefact creation* [23]: higher cost artefacts are more valuable when reused (see e.g., 5,24). While there are other benefits to reuse, this low cost of creating artifacts may not motivate actors to invest in costly and time-consuming reuse practices. *I2) The decentral way of citizen development* [14]: Citizen developers usually operate in specialty departments across the organisation [3,25,26]. The decentral nature of development and a possible lack of communication and access can complicate reuse (see e.g., 5,24). *I3) The developers literacy in*

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reuse techniques: Citizen Developers have usually not undergone formal training in IT development [14]. Therefore, their knowledge on how to reuse or create reusable artefacts may be lacking.

To counteract these issues, research, therefore, needs to find solutions that A) offer suitable technological and organisational measures to reduce the effort needed to reuse low-code artefacts (I1+I3), B) allow for organisations to govern and maintain reusable artefacts (I2) and C) aid citizen developers in creating reusable artefacts and systematically applying reuse without requiring extensive training or constricting the 'quick' development of low-code solutions (I2+I3).

The planned dissertation is embedded into a research project with 6 participating organisations planning to build capabilities in BPA and in low-code reuse. The collaboration with these organisations will allow to create managerial and technical reuse concepts within the thesis and test them in different configurations.

2. The State of Reuse in BPM Research

The BPM field has come up with several concepts that aid the reuse of artefacts and the associated processes or concepts:

1. Sub-Processes allow modellers to bundle parts of a process into a module that can then be re-used several times throughout the process or in other processes (see, e.g., 27–29).
2. Reusing processes models when modelling for a different purpose Process models are created for a specific purpose [29]. For other purposes the model may have to be remodelled or adapted. Existing models can be used as a base for this.
3. Reference Processes are generalised processes that claim to be 'ideal' within an industry. They can be created with configuration points that allow reuse in broader contexts [30,31].
4. Service oriented architectures use loosely coupled automation modules containing one specific business functionality that are configured into software services aligned with processes. The modules can be re-configured (and thus re-used) when processes change (see e.g. [7,9,32]).
5. Robotic Process Automation (RPA) is often utilised to interact with legacy systems through their User Interface and make them compatible with changed processes [17,33]. This basically leads to the reuse of existing software in new processes without changing the existing artefacts.

Some of the concepts mentioned above have also been linked, creating further reuse opportunities (see e.g. 32). While these concepts exist, reuse in BPM, apart from sub-processes and RPA does not seem to have gained widespread acceptance in practice yet.

In addition, BPM research still calls for more concepts to further reuse both of BPM and BPA elements [17,20–22], indicating that reuse and its support is not yet "solved" in the field. One issue is that the single process focus of BPM hinders reuse by creating "process silos" [34].

3. Research Questions and Intended Solution

Within my thesis, I plan to address the aforementioned issues in the form of three research objectives that each include two questions. Table 1 gives an overview of these objectives and questions, the methods planned to address these questions and the planned solutions to satisfy the research objectives.

First, I plan to create an understanding of how the reuse of low-code applications is currently performed in BPM (Objective 1). The theoretical understanding obtained in this way will be instrumental in guiding further research into low-code automation reuse. The first research question (RQ 1) is: "How are artefacts reused within and across organisations" To answer this RQ, I plan to apply Grounded Theory [35,36] to the literature on the reuse of low-code artefacts and automation within business processes in general (to uncover transferable concepts) and the previously mentioned interview to uncover and analyse existing concepts from the literature and from practice. The second RQ in Objective 1 (RQ 2: "Which parameters support or hinder the reuse of such artefacts?") aims to uncover how success in low-code reuse can be achieved. First, the

factors influencing the success of low-code reuse and mitigating measures are identified in the interviews and the literature using Grounded Theory. In a second step, their interplay is determined using configurative methods. In this research objective I also plan to uncover how the reuse of low-code applications differs in comparison to regular IT (RQ3).

So far, I conducted interviews with 24 employees of seven organisations (companies) and one employee of an RPA consultancy. I will include more interviews with different employees from the same organisations (target: ~40). The goal of this step is to find different actors approaches to reuse. In addition, I will add approximately two more consultancies to get a broader overview of reuse concepts also including expert opinions on the inter-organisational reuse of artefacts. Additionally, I plan to interview three vendors of low-code tools to uncover how they plan to support reuse. Vendor-specific differences and their future plans for reuse may influence the thesis.

Table 1: Research Objectives and Research Questions

RQ	Method	Solution
Objective 1: Understanding how the reuse of low-code automation artefacts is currently performed in BPM.		• Theoretical understanding on how organisations currently conduct low-code reuse.
RQ 1. How are artefacts reused within and across organisations?	Grounded Theory	
RQ 2 Which parameters support or hinder the reuse of such artefacts?	Grounded Theory and Coincidence Analysis	
RQ3: How does low code reuse differ from the reuse of regular IT artefacts?	Grounded Theory	
Objective 2: Enabling citizen developers to reuse low-code automation artefacts.		• Design principles for reusable automation artefacts and reuse-oriented low-code development software.
RQ 4. How do low-code automation artefacts need to be designed, documented and presented so they can be reused?	Design Science Research	
RQ 5. Which mechanisms can aid citizen developers in systematically conducting reuse without inhibiting artefact creation greatly or requiring extensive training?	Design Science Research	
Objective 3: Managing reuse on the organisational level.		• Guiding principles for organisations to form environments conducive to reuse. • Guiding principles that organisations can use to find and manage reuse artefacts.
RQ 6. How can organisations create environments that improve low-code artefact reuse form a planning and organisational view?	Design Science Research or Action Research	
RQ 7. How can organisations identify and manage low-code IT artefacts suitable for reuse across processes and departments?	Design Science Research	

After establishing this groundwork, I plan to follow a second research objective; Objective 2: "Enabling citizen developers to reuse low-code automation artefacts". With this objective, I plan to create design principles for reusable automation artefacts and reuse oriented low-code development software [37]. Therefore, with RQ 4 ("How do low-code automation artefacts need to be designed, documented and presented so they can be reused?") I plan to uncover the properties low-code artefacts must have in order to be easy to reuse and bring the maximum value when reused. This also includes the characteristics that make citizen developers perceive the artefacts as useful during development. The results from this question will also be helpful in RQ 5 ("Which mechanisms can aid citizen developers in systematically conducting reuse with-out inhibiting artefact creation greatly or requiring extensive training?"). Under this RQ, I plan to find factors (i.e. design decisions) that influence reuse in low-code development platforms.

Both RQs in Objective 2 are planned to follow a Design Science Research (DSR) approach [38]. Here, I plan to conceptualise reusable low-code applications with varying characteristics, and a

prototypical development environment. Prospectively, the tool is planned to measure the influence of design decisions on reuse through metrics (e.g., number of times artefact x is reused / number of views of artefact x). The prototype is planned both as a platform for sharing reusable components and knowledge on the components and for discussion on reuse itself. It will support several layers of reuse (see Chapter 4 Preliminary Results), different technologies (e.g. low-code artefacts and microservices) and different granularities (e.g. a simple task or an entire invoice processing pipeline). Where possible, the processes corresponding to the reusable artefacts will be displayable and navigable (e.g. clicking on a process step will show the entry for the reusable component). Beyond the scope of this thesis, the platform could be extended to become a reuse oriented BPM platform. The reusable components (and the corresponding processes) developed during research will also be made available using the prototype to the organisations with which the interviews were conducted. Through this, the components' reuse and interaction with the system can be observed in the real world and gradually optimised (e.g., through action research).

The third research objective investigates how organisations can manage reuse on an organisational level, leading to guiding principles on creating environments conducive to reuse (within the organisation or possibly beyond) and finding and managing reusable low-code artefacts. RQ 6 ("How can organisations create environments that improve low-code artefact reuse form a planning and organisational view?") builds on the results of RQ 5 and aims at finding mechanisms organisations can employ to further reuse. I plan to follow a DSR approach for the artefacts, while methodical and organisational measures will be implemented in an action research approach.

One (already started) action is a monthly teaching and discussion session on BPM and the reuse of related artefacts with the six aforementioned organisations. Over time, I plan to track the achieved changes in reuse. The proposed repository will also be available to the organisations, and I plan to track the factors influencing adoption or refusal to adopt. This is done to either validate the system or to be able to adapt it based on the feedback retrieved. Lastly, RQ 7 ("How can organisations identify and manage low-code IT artefacts suitable for reuse across processes and departments?") aims to counteract the governance issues mentioned above regarding low-code reuse, especially in organisations employing decentralised development. Results will be validated with the partaking organisations, in a clinical research approach [39], or (if this is not possible) in interviews.

4. Preliminary Results

The first research conducted was on the goals motivating organisations to utilise low-code development in the first place using the example of Robotic Process Automation. This was done to uncover which characteristics organisations value in low-code and how these characteristics could be amplified (or at least be undisturbed) by reuse. 28 goals that organisations pursue when implementing and using RPA were uncovered [40]. Organisations deemed the cost benefits to be especially valuable within these goals. To be relevant for practice, this thesis therefor has to focus on reducing the development cost of low-code components further. This first paper contributes to the understanding sought in Objective 1.

A literature review on the reuse of process automation solutions (aiding Objective 1) is currently under review. It uncovers and summarises the different characteristics of reusable artefacts described in the literature (e.g., size, planned reuse methodology) and corresponding technologies of reuse.

Based on the findings of this literature review, I developed a first draft of design principles for organisational reuse environments in a DSR-like approach (aiding Objective 3). The resulting research in progress, including the first rigour and relevance cycles, is also under review. The principles will be further refined as the thesis progresses.

In addition, I am working on an extension to the BPM Lifecycle by Dumas et al. [29] to systematically include reuse considerations in each of the lifecycle steps for Business Processes themselves and the associated artefacts (aiding RQ4, RQ5).

5. Potential threats

In its later stages (Obj. 2 and 3), this research highly depends on the organisations' participation. The DSRs relevance cycles and the planned action research can only be conducted if most organisations stay involved in the project. To achieve this, the organisations will be continuously offered value through the previously mentioned training and the developed reusable automation solutions. As continuously generating and providing these results will be time consuming for me, the competition for available working time may be a threat to the academic contributions.
A risk to the relevance of this work is that in certain circumstances low-code reuse may not be financially worthwhile in practice. However, the insights gained in this thesis would still be useful as there are other benefits to reuse applicable (such as available personnel, personnel skills in new development, quality, reduced maintenance or even environmental aspects).
Another threat to the works success is the abundance of reuse methodologies and technologies in the fields of Systems Engineering and Information Technology. A current systematic literature review on the technologies in those fields does not exist due to the immense number of publications and reuse technologies. Therefore, an exhaustive overview of available technologies and an evaluation of their potential for low-code reuse can also not be part of this thesis.

6. Relevance to the BPM Field

This thesis advances the literature in the BPM field in several ways. First this thesis provides a understanding and common vocabulary on reuse in the BPM field (Objective 1). Different research streams connected to BPM (like reference modelling [41], RPA [16,21] and process mining [42,43]) have developed concepts and thoughts regarding reuse. In this thesis, I plan to systematise these concepts and (if existent) uncover further concepts from practice that can then be analysed in research. The developed understanding will allow researchers to draw on the uncovered concepts and use the unified understanding to aid communication across these fields.
The insights into low-code reuse could also allow researchers to evaluate current BPM and low-code development initiatives regarding reuse. The overview of relating concepts created will allow them to implement such concepts into procedural models and support them in evaluating artefacts and procedural models. The understanding of factors that support or hinder reuse can further aid researchers shape those effects when creating new concepts for reuse. Practitioners can use these insights to align BPM and BPA projects.
The insights into how reusable automation components need to be designed (Objective 2) could allow researchers to develop different reuse methodologies for low-code components. The ability to design low-code artefacts to allow them to later scale in different processes has been identified as a critical success factor [16,17]. The insights created on how reusable artefacts should be designed to allow such transfer to other business processes [16] and the mechanisms created to help citizen developers implement such reusable artefacts will help practitioners on the one hand. On the other hand, it will allow researchers to compare the factors relevant to citizen developer [14] reuse to 'traditional' reuse. The further insights into when citizen developers perceive reusable artefacts as useful will allow further insights into the social and cultural aspects of BPM, such as the capability areas of "Process Values & Beliefs" or "Process Attitudes & Behaviors" [44]. It will also allow to design low-code environments in a way that enables reuse.
The managerial aspects covered in Objective 3 will help uncover the organisational factors needed to successfully scale Business Process Automation. It has been identified that the following of processes creates 'silos' that hinder reuse [34]. Continuous knowledge management, focus on scalability and focus on creating re-usable automation solutions are critical factors in business process automation [16]. This thesis therefore attempts to uncover how organisational and technological environments that are conductive to reuse can be formed. These insights shed further light on the social influence on process automation. Finally, this thesis aims to advance first efforts (see, e. g., [32]) to transfer automatic methods of automation artefact discovery (see, e.g., [45]) into BPM for the automatic discovery of process automation artefacts.

7. References

[1] M. Weske, Business Process Management, Springer, Berlin, Heidelberg, 2019.

[2] M. Rosemann, J. vom Brocke, The Six Core Elements of Business Process Management, in: J. vom Brocke, M. Rosemann (Eds.), Handbook on Business Process Management 1: Introduction, Methods, and Information Systems, 2nd Edition, Springer, Berlin, Heidelberg, 2015, pp. 107–122.

[3] V. Borghoff, R. Plattfaut, Steering the Robots: An Investigation of IT Governance Models for Lightweight IT and Robotic Process Automation, in: A. Marrella, R. Matulevičius, R. Gabryelczyk, B. Axmann, V. Bosilj Vukšić, W. Gaaloul et al. (Eds.), Business Process Management: Blockchain, Robotic Process Automation, and Central and Eastern Europe Forum, Springer, Cham, 2022, pp. 170–184.

[4] Jeston, John, Business Process Management: Practical Guidelines to Successful Implementations, Fourth edition, Routledge, New York, 2018.

[5] Y. Kim, E.A. Stohr, Software Reuse: Survey and Research Directions, J. Manag. Inf. Syst 14 (1998) 113–147.

[6] M.D. McIlroy, Mass Produced Software Components, NATO Software Engineering Conference. Garmisch, Germany, 7th to 11th October 1968 (1968).

[7] R. Baskerville, M. Cavallari, K. Hjort-Madsen, J. Pries-Heje, M. Sorrentino, F. Virili, Extensible Architectures: The Strategic Value of Service Oriented Architecture in Banking, ECIS 2005 Proceedings (2005).

[8] S. Bērziša, G. Bravos, T.C. Gonzalez, U. Czubayko, S. España, J. Grabis et al., Capability Driven Development: An Approach to Designing Digital Enterprises, BISE 57 (2015) 15–25.

[9] A. Becker, T. Widjaja, P. Buxmann, Value Potentials and Challenges of Service-Oriented Architectures, BISE 3 (2011) 199–210.

[10] J. Mendling, B.T. Pentland, J. Recker, Building a complementary agenda for business process management and digital innovation, European Journal of Information Systems 29 (2020) 208–219.

[11] W.M.P. van der Aalst, M. Bichler, A. Heinzl, Robotic Process Automation, BISE 60 (2018) 269–272.

[12] G. Allen, J. Parsons, Is Query Reuse Potentially Harmful? Anchoring and Adjustment in Adapting Existing Database Queries, Inf. Syst. Res. 21 (2010) 56–77.

[13] U. Apte, C.S. Sankar, M. Thakur, J.E. Turner, Reusability-Based Strategy for Development of Information Systems: Implementation Experience of a Bank, MISQ 14 (1990) 421–433.

[14] Y. Li, R. Huang, Participating in Citizen Development: Theory of Planned Behavior, AMCIS 2022 Proceedings 2 (2022).

[15] R. Plattfaut, Robotic Process Automation - Process Optimization on Steroids?, ICIS 2019 Proceedings 3 (2019).

[16] R. Plattfaut, V. Borghoff, M.E. Godefroid, J.F. Koch, M. Trampler, A. Coners, The Critical Success Factors for Robotic Process Automation, Computers in Industry 138 (2022) 103646, 1-15.

[17] M. Lacity, L.P. Willcocks, Innovating in Service: The Role and Management of Automation, in: L.P. Willcocks, I. Oshri, J. Kotlarsky (Eds.), Dynamic innovation in outsourcing: Theories, cases and practices, Palgrave Macmillan, Cham, 2018.

[18] T.C. Lethbridge, Low-Code Is Often High-Code, So We Must Design Low-Code Platforms to Enable Proper Software Engineering, in: T. Margaria, B. Steffen (Eds.), Leveraging Applications of Formal Methods, Verification and Validation, Springer, Cham, 2021, pp. 202–212.

[19] M. Lacity, L.P. Willcocks, A. Craig, Robotic Process Automation: Mature Capabilities in the Energy Sector, The Outsourcing Unit Working Research Paper Series (2015).

[20] A. Asatiani, E. Penttinen, T. Rinta-Kahila, A. Salovaara, Organizational Implementation of Intelligent Automation as Distributed Cognition: Six Recommendations for Managers, ICIS 2019 Proceedings (2019).

[21] R. Syed, S. Suriadi, M. Adams, W. Bandara, S.J. Leemans, C. Ouyang et al., Robotic Process Automation: Contemporary themes and challenges, Computers in Industry 115 (2020) 103162.
[22] H.A. Reijers, J. Mendling, J. Recker, Business Process Quality Management, in: J. vom Brocke, M. Rosemann (Eds.), Handbook on Business Process Management 1: Introduction, Methods, and Information Systems, 2nd ed, Springer, Berlin, Heidelberg, 2015, pp. 167–185.
[23] S.A.A. Naqvi, M.P. Zimmer, R. Syed, P. Drews, Understanding The Socio-Technical Aspects Of Low-Code Adoption For Software Development, ECIS 2023 Research Papers 357 (2023).
[24] J.S. Poulin, J.M. Caruso, D.R. Hancock, The business case for software reuse, IBM Syst. J. 32 (1993) 566–594.
[25] B. Bygstad, The Coming of Lightweight IT, ECIS 2015 Completed Research Papers (2015).
[26] M.E. Godefroid, R. Plattfaut, B. Niehaves, IT Outside of the IT Department: Reviewing Lightweight IT in Times of Shadow IT and IT Consumerization, in: F. Ahlemann, R. Schütte, S. Stieglitz (Eds.), Innovation Through Information Systems: Volume III: A Collection of Latest Research on Management Issues, 1st ed. 2021, Springer; Imprint: Springer, Cham, 2021.
[27] A.H.M. Hofstede, W.M.P. Aalst, M. Adams, N. Russell, Modern Business Process Automation, Springer, Berlin, Heidelberg, 2010.
[28] Object Management Group, Business Process Model and Notation. 2nd ed., 2014, https://www.omg.org/spec/BPMN, [June 14, 2023].
[29] M. Dumas, M. La Rosa, J. Mendling, H.A. Reijers, Fundamentals of business process management, Second edition, Springer, Berlin, Germany, Heidelberg, 2018.
[30] J. Becker, P. Delfmann, R. Knackstedt, Adaptive Reference Modeling: Integrating Configurative and Generic Adaptation Techniques for Information Models, in: J. Becker, P. Delfmann (Eds.), Reference Modeling: Efficient Information Systems Design Through Reuse of Information Models, Physica, Heidelberg, 2007, pp. 27–58.
[31] W. Derguech, F. Gao, S. Bhiri, Configurable Process Models for Logistics Case Study for Customs Clearance Processes, in: F. Daniel, K. Barkaoui, S. Dustdar (Eds.), Business Process Management Workshops, Springer, Berlin, Heidelberg, 2012, pp. 119–130.
[32] T. Kleinert, S. Balzert, P. Fettke, P. Loos, Systematic Identification of Service-Blueprints for Service-Processes - A Method and Exemplary Application, BPM 2012 Workshops, LNBIP 132 (2012) 598–610.
[33] L.P. Willcocks, M. Lacity, A. Craig, Robotic Process Automation at Xchanging, The Outsourcing Unit Working Research Paper Series 15/03 (2015).
[34] I. Beerepoot, C. Di Ciccio, H.A. Reijers, S. Rinderle-Ma, W. Bandara, A. Burattin et al., The biggest business process management problems to solve before we die, Computers in Industry 146 (2023) 103837.
[35] J.F. Wolfswinkel, E. Furtmueller, C.P.M. Wilderom, Using grounded theory as a method for rigorously reviewing literature, European Journal of Information Systems 22 (2013) 45–55.
[36] A. Strauss, J. Corbin, Basics of qualitative research: Techniques and procedures for developing grounded theory, 2nd ed., Sage Publications, Inc., 1998.
[37] S. Gregor, L. Chandra Kruse, S. Seidel, Research Perspectives: The Anatomy of a Design Principle, JAIS 21 (2020) 1622–1652.
[38] A.R. Hevner, S.T. March, Park,Jinsoo Ram,Sudha, Design Science in Information Systems Research, MISQ 28 (2004) 75–105.
[39] R. Baskerville, J. vom Brocke, L. Mathiassen, H. Scheepers, Clinical research from information systems practice, European Journal of Information Systems 32 (2023) 1–9.
[40] P.A. François, V. Borghoff, R. Plattfaut, C. Janiesch, Why Companies Use RPA: A Critical Reflection of Goals, in: Business Process Management, Münster, Germany, 2022, pp. 399–417.
[41] J. Becker, P. Delfmann (Eds.), Reference Modeling: Efficient Information Systems Design Through Reuse of Information Models, Physica, Heidelberg, 2007.
[42] J. Schneider, S. Seidel, M. Basalla, J. vom Brocke, Reuse, Reduce, Support: Design Principles

for Green Data Mining, BISE (2022).
[43] D. Wegener, S. Rüping, On Reusing Data Mining in Business Processes - A Pattern-Based Approach, in: M. zur Muehlen, J. Su (Eds.), Business Process Management Workshops, Springer, Berlin, Heidelberg, 2011, pp. 264–276.
[44] de Bruin, T and Rosemann, Michael, Using the Delphi Technique to Identify BPM Capability Areas, ACIS 2007 Proceedings. 42 (2007).
[45] T.-D. Han, Automating Reuse for Systems Design, AMCIS 1999 Proceedings (1999).