PUMA - A Java Application for Pattern-based Business Model Adaptation

Ricarda Schlimbach
Technische Universität Braunschweig, r.schlimbach@tu-braunschweig.de

Sören Christmann
Technische Universität Braunschweig, s.christmann@tu-bs.de

Susanne Robra-Bissantz
Technische Universität Braunschweig, s.robra-bissantz@tu-bs.de

Designing a Java Application for pattern-based Business Model Adaptation

Completed Research

Ricarda Schlimbach
TU Braunschweig (DE)
r.schlimbach@tu-bs.de

Sören Christmann
TU Braunschweig (DE)
s.christmann@tu-bs.de

Susanne Robra-Bissantz
TU Braunschweig (DE)
s.robra-bissantz@tu-bs.de

Abstract

PUMA stands for Pattern-based bUsiness Model *A*daptator. Behind it is a Java application designed to teach students in creating business models in volatile, digital environments. Surrounded by the theoretical lenses of Digital Darwinism, its users experience the pattern-based architecture of business models (BM) and the evolutionary process of innovation behind it. Guided by the PUMA, they innovate existing BMs in a divergent-convergent process by first identifying integrated patterns and then adapting them systematically. The artifact was developed using the Design Science Research Paradigm and relies on scientific research proving that innovation processes are mapped by the evolutionary recombination of existing patterns. The implemented divergent-convergent process is intended to promote creativity and versatile thinking. So far, the artifact has been designed and evaluated in three iterative DSR cycles for use in entrepreneurship education. However, our paper also proposes the future transfer of PUMA to new contexts such as medicine or sales.

Keywords

Business Model, Innovation, Digital Darwinism, Creativity, Business Model Patterns.

Introduction

Research shows that entrepreneurship activities are an important pillar for the social and economic development of a country, as they have the potential to raise the entrepreneur's salary, create more jobs, and increase social innovation (Lv et al. 2021). Particularly in the current volatile economic environment, entrepreneurship offers a plethora of opportunities for innovation, but at the same time presents great challenges (Hameed and Irfan 2019). For instance, the increasing complexity of the economic environment and the acceleration of digital transformation in all areas, are forcing companies of all sizes to adapt their business models (BMs) continuously (Schlimbach and Robra-Bissantz 2022; Troise et al. 2022). With unprecedented universality, speed, and intensity, digitalization is accelerating BM's adaptation as a driving megatrend (Dzhukha 2021). Therefore, it is important to prepare the young generation for these challenges at an early age (Hameed and Irfan 2019) by cultivating entrepreneurial qualities such as fostering entrepreneurial skills, creativity, or knowledge of business models and their adaptation in higher education (Otache 2019). Teaching methods and tools also need to change dynamically in this process (Chawinga 2017). In the spirit of experiential learning (Ratten and Usmanij 2021), current theoretical research should be taught practically, so that what is learned can be actively tried out and stimulates creative and hands-on thinking (Mandel and Noyes 2016) – established methods like divergent-convergent ideation processes (cf. p.3) might support along that way (Razumnikova 2013).

The goal of our design-oriented contribution is to develop an IT artifact meant for teaching university students the theoretical basics of BMs and their adaptation (e.g., pattern-based anatomy; evolutionary innovation processes along with these patterns) while enabling them to engage in practical analysis, creation, and adaptation of implemented BMs.

Thereby, we regard the interlocked integration of two, typically isolated theoretical research strands for BM creation and adaptation into our tool as central:

> 1) From a systems theory perspective, the process of adaptation and selection of value creation architectures that fit the environment takes the form of an autopoietic, evolutionary process (Luhmann 2012). The fit to the environment determines which BM patterns will prevail on the market and reproduce themselves more frequently due to their fit to market needs (cf. section of Digital Darwinism).
>
> 2) In addition, however, adaptation can also be consciously shaped by human BM creators who adapt its elements (e.g., Abdoun and Ibrahim 2018). The targeted selection of patterns that have proven particularly effective for the current market situation can contribute to the conscious creation of suitable BMs and their continuous adaptation (Csik 2014).

The scientific literature contains numerous articles that either theoretically analyze the evolutionary change processes and innovation dynamics from (1) (e.g., Downs and Velamuri 2018; Mast 2017; Schlimbach 2021) or address the more practical design of a proactive BM creation process (2) (e.g., Csik 2014; Gassmann et al. 2014). However, it is hard to find an application, which links the interrelationships of the transformation processes of both levels and guides the practical adaptation of BMs in learning environments. Especially in the entrepreneurship education IT artifacts to teach and learn the evolutionary adaptation processes of BMs that can be broken down to underlying patterns are lacking (Schlimbach and Robra-Bissantz 2022). Yet, it is precisely important to convey the synergy of the two perspectives to students so that they understand entrepreneurship not only in the narrow sense (starting a business), but in the broader sense (recognizing patterns and opportunities, and intervening productively in the innovation process) (Lv et al. 2021). In this way, we can foster entrepreneurial skills early on in an increasingly complex and uncertain society. We would like to contribute by using the design-oriented paradigm of Design Science Research (DSR) (Hevner 2007) to design a Java application for the IT-supported adaptation of BMs, which - based on the scientific rigor of BM research - produces a practice-relevant artifact (Hevner et al. 2004) taking into account the connections from both perspectives (1) and (2). This creates the potential for students to understand innovation as a pattern-based, self-evolving process, but one in which they can actively intervene for purposeful co-design.

Our paper is organized as follows: First, we summarize the research background on digital Darwinism, pattern-based BMa, and convergent-divergent reasoning as theoretical concepts for the tool under development. We then explain the DSR paradigm in a research context before presenting the resulting Java tool PUMA and the iterative evaluation results. Based on this, we discuss implications for research and practice, but also admit limitations. In the conclusion, we summarize our results and give an outlook on potential future research avenues.

Research Background

Digital Darwinism

Digital Darwinism results when technologies and ecosystems change faster than the ability of companies to adapt to these changes (Kreutzer and Land 2015). Thus, it is not the competitor with the most capital, power, or experience that prevails, but the most adaptable to change (Kreutzer and Land 2015; Schlimbach and Robra-Bissantz 2022). Understanding the importance of adaptable BMs and guiding the adaptation process is a big challenge – the terminology and mechanisms from evolution theory make complex adaptation and selection processes easier to understand and more tangible. The current volatile developments lead us to expect that the pressure to innovate will increase even further (Troise et al. 2022). In addition, every innovative BM fundamentally holds the potential to provoke alignment processes in its assigned industry (or even beyond) and to thereby completely redefine the rules of the game and the dominant value creation logic in the competitive environment (Mast 2017). For example, thanks to its use of digital technology in providing mobility as a service, Uber has largely driven the cab industry out of the market in many countries without owning a single own fleet vehicle (Kreutzer and Land 2015). Amazon Prime has become the largest and most lucrative online video store in the world without having to operate physical warehouses of footage, and Airbnb is upending the hotel industry internationally without maintaining any sleeping facilities (Schrader 2017). Overall, the practical examples show that in the course of the selection process, only those companies survive that succeed in integrating patterns into their BM that are particularly suitable in the current environmental situation (e.g., digital platforms in digital service ecosystems), adapting them flexibly while taking market needs into account, and using them profitably for themselves (Schlimbach 2020). Following the law of requisite variety (Ashby 1956) supportive dynamic instruments are needed to counter external complexity with equally complex systems. An approach in that context is to identify BM patterns that are particularly well suited to the environment at an early stage and to adapt the current BM accordingly in a guided process with a high variety of their combination and innovative application to ensure its survival in the market (Schlimbach and Robra-Bissantz 2022).

Pattern-based (BM-) Innovation

By analyzing 237 representatively selected BMs, Gassmann et al. (2014) were able to show that 90% of the BMs that have emerged since 1960 can be reconstructed by combining 55 basic patterns. Since then, additional BM patterns, especially those arising from the digital transformation, have been added[1]. These include, in particular, mostly data-driven shared value creation from a network of actors, the shift from a product-centric to a service-centric logic, increased customer-centricity as a market expectation, and other adapted aspects to the transforming environment. This approach of pattern-based innovation through analogy building is not new. As early as 1939, Schumpeter argued that 90 percent of all innovations would result from the recombination of existing solutions and concepts, which was scientifically confirmed 45 years later (Altshuller and Williams 1984; Croitoru 2017). When the study was extended to a patent volume of two million in 2007, the relative share of patent innovations traceable to Altschuller's 40 innovation principles (1999) exceeded 99 percent (Souchkov 2007). As a result, less than one percent of innovative technologies are actually novel in their mechanics, but rather make use of existing patterns that are linked together in a novel way or embedded in other contexts (Csik 2014). The recombination of patterns is an evolutionary principle in a broader sense because it means that individual elements of BMs can also be found in subsequent value creation architectures or, lead to BM innovation through their fusion or novel combination (Schlimbach 2020).

Our prototype is based on this scientifically proven foundation (*rigor*) that innovation follows an evolutionary process by combining existing patterns in a novel way. Research shows that a modular system consisting of 55+ BM patterns is not only sufficient to map almost all existing BMs down to their inherent patterns, but to generate innovative BMs from them as well (Csik 2014; Gassmann et al. 2014).

Convergent-Divergent Thinking

With divergent and convergent thinking, two different thinking processes are typically involved in creative ideation processes (Razumnikova 2013). Divergent thinking is the conscious opening of the thinking process to surprising knowledge contexts and thus new solutions or ideas (Runco 2013). Convergent thinking describes however a thinking style, which is characterized more strongly by linear thinking processes and evaluates the ideas after rational arguments regarding their usefulness (Lubart 2016). The distinction between the divergent and convergent thinking is reflected in numerous so-called *creative problem-solving models* to support creative solution finding because initially divergently created ideas for multiple solution approaches are considered that way and then transformed into convergent idea selection to force on those ideas that appear particularly effective (Csik 2014). As a result, we decide on a divergent-convergent reasoning process for pattern-based BM adaptation to be implemented in our artifact in order to enable students to first analyze the patterns of an existing BM before adapting it by systematically choosing matching patterns from a variety of options. That way, we intend to foster the user's creativity.

---

[1] cf. https://miro.com/app/board/o9J_khzsheQ=/?moveToWidget=3074457359960751965&cot=10

Methodology

DSR proposes clear guidelines for understanding, executing, and evaluating research (Hevner et al. 2004). Its goal is to ensure that artifacts are designed based on business needs and requirements (*relevance*), while being built upon applicable knowledge from grounded theories, frameworks, and methods (*rigor*). Artifacts emerge iteratively from a design-oriented process. Given that perspective, our IT artifact arises from the actual need (relevance) for a guiding tool to teach the creation and adaptation of BMs that are more appropriate to the volatility of digital ecosystems (Schlimbach 2021). Pattern-based innovation, divergent-convergent thinking, and the perspective of Digital Darwinism provide the theoretical foundation (rigor). The artifact was developed in an iterative process modeled on Hevner's (2007) DSR paradigm. We completed three iteration cycles lasting about two months each and thus successively contributing to the improvement of the educative IT artifact as illustrated in Figure 1.

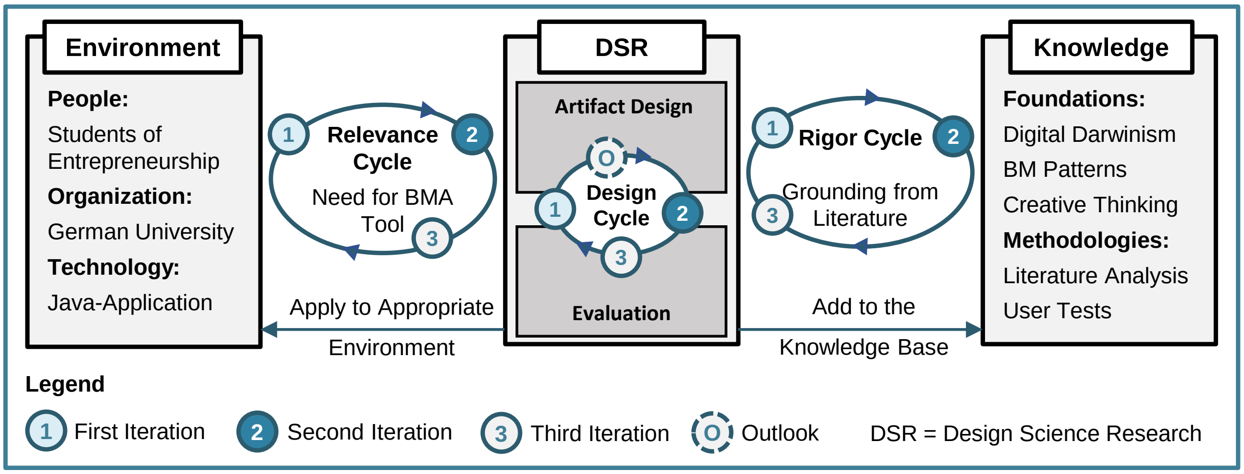


Figure 1. Application of DSR in three Iterations

During each relevance cycle, the practical relevance was aligned through close exchange with other researchers and teachers in (academic) entrepreneurship education to derive requirements for the BM adaptation tool, and the respective development status of the application was evaluated with successive user tests within each iteration. Five students as potential future target users tested the artifact individually in detail along each of the three design cycles by evaluating the categories of the user interface, functionality, comprehensibility, bugs, content, and other improvements. For this purpose, each of the user test-takers individually worked through all the functionalities of the artifact implemented at the respective stage and was asked to articulate aloud any thoughts or problems arising in the process guided by the instructions in the tool as suggested by Someren et al. (1994). Each sample run lasted 1-2 hours followed by an open evaluation discussion in which the respective test person commented on the previously listed evaluation criteria and was asked to make concrete suggestions for improvement. Additionally, overall impressions of the artifact in regards to its suitability for self-usage, functionality, and user experience were discussed and evaluated by the students. From their feedback, adjustments were then incorporated into the next iteration cycle. The qualitative evaluation feedback of the students documented the continuous improvement within the DSR process.

Results

The application of the DSR paradigm led to the following basic requirements for the problem-solving artifact: An easy-to-understand and user-friendly application should be designed that supports the pattern-based adaptation of BMs in a divergent-convergent process, drawing on the 55+ BM patterns and the thinking glasses of Digital Darwinism. The application of the software has the overarching goal of teaching students in entrepreneurship education the pattern-based evolution of BMs and supporting them in their purposeful adaptation against the backdrop of Digital Darwinism.

In the first DSR iteration cycle, the basic logic and functionality of the application were programmed as a rich client project in JavaFx, followed by extended functionalities and improved user experience design in the second cycle and additional content aligning to Digital Darwinism and further enhancement in the last iteration. The next section presents the current state of the Java application after three DSR iteration cycles.

Introducing PUMA

Technical Concept

PUMA was programmed in Java version 11, using Amazon's Java Development Kit Corretto. Eclipse Rich Client Project (RCP) was used as Integrated Development Environment to ensure the later extensibility of the content. GitHub was chosen for versioning the program code. The graphics and images embedded were edited with Adobe Photoshop Creative Cloud or created in the same application. The intro video was edited and rendered using DaVinci Resolve 17. We edited the created sound files with Audacity and recorded the visual components using Open Broadcaster Software. The creation of an *.exe file was done with Maven. To run the program, an x86 computer with Windows operating system needs to be installed. The main class of the program is the GMM-Part class. It contains all data structures that store relevant data for the use of the application, which must be passed along the process phases. Implemented BM patterns are thereby assigned to different pattern trees grouped by content and called in the background via the pattern tree list. For instance, there is a decision tree named “Research and Development” (R&D), which brings together the interwoven BM patterns of *Reverse Engineering*, *Reverse Innovation*, *License*, and *Make More* of it as individual branches. Specific interrogative questions (yes/no) ask first at the tree level (e.g.: Is R&D part of your core business?) and then at the pattern level (e.g.: Is your R&D currently inspired by basic inventions from developing countries?) whether the BM pattern fits the user's current BM. If the answer is no, the tree or respectively the pattern is skipped. In the next stage, it is evaluated whether currently not integrated BM patterns appear suitable for adaptation following the same logic. The processing logic successively runs through stored decision trees in the backend and thus successively excludes non-matching patterns. In contrast, fitting patterns are displayed to the users with an explanatory text, visualization, and examples for application from well-known companies. The text data import is done in the background using a map as a data structure, which stores data with a key and extracts it as "GMM.txt" and imports it into the program. The same procedure applies to all other data imports (e.g., explanatory video, texts, graphics) and allows them to be flexibly exchanged or adjusted.

Process Phases

The core educative idea behind PUMA is the following: Students as users are introduced to the terminology of Digital Darwinism and sensitized to the relevance of the adaptability of BMs. Interrogative questions about their current BM decode recognized BM patterns with the help of decision trees operating in the background and subsequently suggest further, not yet implemented BM patterns, which are supposed to stimulate the adaptation of an existing BM. In the course of this, the user passed through six phases:

Phase 1 – Intro & Video Tutorial (skippable)*:* An introductory video starts playing by explaining the program usage and theoretical framework of Digital Darwinism (Kreutzer and Land 2015), as well as pattern-based BM innovation with the need for constant adaptation in the VUCA world (Schlimbach 2020).
Phase 2 - Recognition of Business Logic: Answering four questions to capture the currently implemented business logic via the four dimensions (what?, who?, how?, value?) of the magic BM triangle (Gassmann et al. 2014).
Phase 3 - Pattern Recognition: Decomposition of one's own BM into inherent patterns according to the patterns of the BM Navigator (Gassmann et al. 2014) through targeted interrogative questions that expose the existing integration of a pattern in the current BM.
Phase 4 - Pattern Adaptation and Idea Development: Suggesting still unconsidered BM patterns and encouraging their adaptive integration into the current GM and inspiring idea development with accompanying questions based on Phase 3.
Phase 5 – Result Summary: A result overview summarizes the patterns currently implemented in the BM and the selected proposed new patterns for adaptation.
Phase 6 – Evaluation & Selection: Comparative evaluation of the BM ideas by having the user plotting them in a 4-quadrant scheme along the axes expected implementation effort (x-axis) and expected impact (y-axis) to support the determination of implementation priority.

Here, PUMA combines the autopoietic evolutionary character of the innovation process with the proactive intervention of the learner, in that the tool explains both strands in theory on the one hand (phase 1) and makes it possible to experience both perspectives on the other. For example, in phase 3, the user recognizes that individual patterns cluster in certain contexts (e.g., *e-commerce* in digital BMs or *rent instead of buy* in contexts where sustainable use is considered more important than ownership as a status). At the same time, however, ideation in phase 4 also motivates active intervention, in that the user specifically selects promising patterns and adapts his BM accordingly. As a result, students learn by experience that they do not have to watch until the system (the market in Digital Darwinism) self-referentially reproduces the patterns best adapted to the environment and displaces inferior BMs, but can proactively shape them. Figure 2 illustrates the flow of PUMA along with these phases from the user's perspective and complements it with the associated theoretical groundings and phase images used in the application.

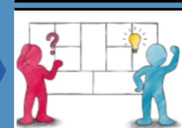
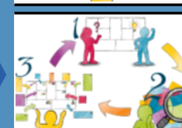
Phase	Scientific Grounding	Content of the Phase	Image
1 **Intro & Video Tutorial**	▪ Digital Darwinism ▪ Adaption of Business Models (BMs) as an evolutionary process ▪ Pattern-based innovation	▪ Video tutorial introducing ○ Digital Darwinism as a thinking frame ○ pattern-based process of innovation ○ usage of the Java-application PUMA	
2 **Recognition of BM Logic**	▪ Magic triangle of Business Model Navigator (BMN) ○ 4 Core Questions (4CQ) ○ 3 Core BM Elements (3CE)	▪ Reflecting on the current BM ○ 4CQ: Who? What? Value? How? ○ 3CE: Value proposition, value chain and revenue model	
3 **Pattern Recognition**	▪55+ BM Patterns of BMN	▪ Query of 20 interrogative questions so that PUMA can draw conclusions from them about the integrated patterns in current BM → Display of identified pattern cards	
4 **Pattern-based Ideation**	▪ 55+ BM Patterns of BMN ▪ BM Adaption as an evolutionary Process	▪ Proposal of at least 3 additional BM pattern to adapt current BM ▪ Questions to confirm their fit ▪ Guiding BM ideation instructions	
5 **Result Summary**	▪ Guiding questions to create and reflect (digital) BMs from previously selected patterns	▪ Overview of BM pattern cards ○ recognized patterns from phase 3 ○ patterns used for ideation in phase 4 ▪ Summary of the user's answers to questions	
6 **Evaluation & Selection**	▪ Adapted matrix for effort/impact-ratio of the BM adaptation ideas	▪ Illustration of up to 9 BM adaptation ideas as colored bubbles that can be placed via drag and drop on a 4-quadrant scheme to visualize their expected value comparatively	

Figure 2. PUMA Process in 6 Phases

Scientific grounding based on (Gassmann et al. 2014; Kreutzer and Land 2015; Schlimbach 2020)

To ensure that PUMA supports independent learning without a human tutor, there are numerous info buttons implemented, which provide tips on the operation or concisely explain keywords. For those interested, reference is also made to the sources of theoretical scientific grounding of the embedded research, so that more in-depth study is encouraged. In addition, free text fields pop up in phases 2 and 4, inviting the user to take notes by answering guiding questions, e.g., to define the current BM by answering four core questions (phase 2) or by writing down ideas on how to apply a proposed pattern to the BM (phase 4). In phase 5 all notes taken are shown again to summarize adaptation ideas and facilitate the evaluation and selection phase of adaptation ideas to eventually implement.

Iterative Evaluation

Subsuming the user test duration from the 12 user tests results in a total duration of approximately 20 hours, during which detailed user feedback was obtained from five student testers. Students 2-4 tested PUMA three times each after the completion of every iteration cycle, whereas tester 1 had to be replaced by another tester (student 5), due to a lack of availability, from the second evaluation onwards. The user test takers were deliberately selected from the pool of potential future users, who, however, show a heterogeneous spectrum concerning prior subject knowledge, their perspective, and the progress of their own studies (freshman - research assistant). This reflects in the best possible way the interdisciplinary entrepreneurship education at the TU Braunschweig, where the tool was developed: Entrepreneurship is not a major in itself, but Entrepreneurship courses bring students from different disciplines together to develop BMs from the synergy of diverse study backgrounds.

Student 1 is 26 years old, male, and works in the field of IT security. He has studied administrative informatics. His feedback should help in the area of programming the artifact. Respondent 2 is 28 years old, female, and works at a university as a research assistant. She has studied information systems engineering. Furthermore, she is working in the teaching area and thus should represent the view of the later use for teaching. Student 3 is 29 years old, male, and studies information systems engineering in the master's program. He represents the view of students in their daily study life. He was selected for his lack of contact with IT development or entrepreneurship education so he should disclose information about the comprehensibility of the application without prior knowledge. Test person 4 is 21 years old, male and a trainee teacher and is to provide didactic impulses. Student 5 is male, has already completed his business informatics studies, and is currently working professionally in Java development, so he is particularly well placed to assess the technical implementation of the application. Figure 3 illustrates the test takers' feedback in the three DSR cycles along with the predefined evaluation criteria.

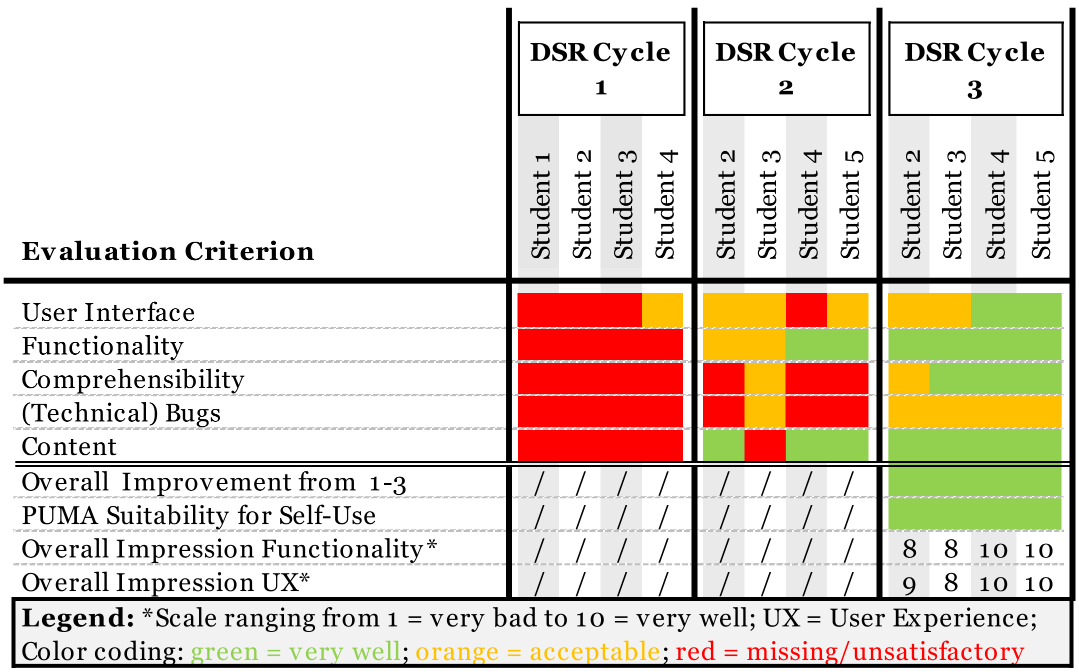


Figure 3. Evaluation Results

The improvement from one cycle to the next mainly results from the suggestions of the user tests, which were then implemented in the following cycle along with enhancements in the functional scope. For example, the testers suggested making the tool more dynamic by playing jingles and an explanatory video, they exposed duplicate BM patterns and spelling errors or contributed to the comprehensibility of the application by addressing where additional explanatory texts, pop-ups, or labels were needed. The result summary feature in phase 5 was also proposed by the user testers, who desired to finally list all BM patterns at a glance so that they could select them again and review them in more detail.

While in the first cycle only one prototypical pattern recognition tree with five assigned patterns and five pattern adaptation trees with three integrated patterns each were stored for possible adaptation suggestions, we enriched these to 14 pattern adaptation trees with 34 integrated patterns in the second cycle up to 48 dynamically traversed integrated patterns in the third iteration cycle. The second iteration was aimed at expanding functionality and improving the user experience. In the course of this, we harmonized the application to uniform English language, deposited an explanatory video on the use of the application and the contexts of the theoretical foundation of our concept, added info text buttons and guiding questions for the design of the individual BM patterns, as well as an interactive evaluation and selection phase to reflect on the adapted patterns supported by an overview of notes taken by the user along with the process steps. In the third and final DSR cycle, we focused on expanding the content and embedding Digital Darwinism as framing story into the application, fixed bugs, and made further visual improvements (e.g., a more vivid video, newly created logo, and graphics for each phase). In the final overall evaluation, all test takers rated the perceived degree of improvement along with the three DSR cycles and their own usability of PUMA consistently positively, giving the user experience of the application 36 out of a possible 40 points and the overall impression 37 out of 40 points. The positive quantitative feedback is also reflected in the students' comments, for example, student 4 sums up, "PUMA has evolved in looks, functionality and user experience from iteration to iteration and has integrated my feedback very well. I learned a lot about business models and it was actually fun." Student 2 adds, "video and the context of Digital Darwinism support well when using it – that makes it much easier to remember technical terms." Nevertheless, they also addressed potential for further improvement for possible future iteration cycles, such as fixing formatting errors of texts and buttons, elaborating a corporate design, or extending PUMA to accompany the implementation phase of adapted BMs.

Discussion

Implications for Research and Practice

The contribution of our work is threefold. First, our IT artifact combines the evolutionary perspective with the interpretation of BM innovation as an autopoietic system (Luhmann 2012) with the proactive design perspective of conscious intervention in the innovation process through targeted adaptation (Gassmann et al. 2014). The link here is pattern-based innovation processes because on the one hand these patterns automatically assert themselves in the course of evolution according to their fit with the environment, and on the other hand, they can also be actively selected and consciously integrated into novel or adapted BMs.

Secondly, with PUMA we provide a fully functional Java application that supports the communication of the interrelationships of pattern-based BM adaptation in Digital Darwinism and creative idea generation in a divergent-convergent process. Especially in an era where teaching and learning are increasingly shifted to the digital space (Pettersson 2021), the tool enriches through its location and time flexible usability without the need for a (physical) workshop with a human host.

Third, PUMA provides a technical framework for potentially all adaptation or innovation processes that are pattern-based and can be mapped in a divergent-convergent process. Since importing and adapting the content is flexible, transferability to new content and contexts remains easy. For example, technological patterns or evolutionary analogies from flora and fauna could be stored in the Java application, leading to innovation through an evolutionary adaptation process. Even completely new fields of application, such as in medicine, are conceivable: First, the clinical picture might be recorded based on fed-in patterns, to then present various treatment options with the respective potentials and side effects and select a suitable one for the patient. Other examples could be vehicle configurators in which patterns are first captured for recording the mobility needs on the part of the prospective buyer to then suggest various packages of mobility or vehicle components that match the buyer's preferences by still leaving room for individual adaptation. PUMA could also potentially support salespeople in recognizing and responding in a targeted manner to customers' purchase decisions and behavioral patterns. The areas of application are thus versatile. However, the prototypical tool presented here is meant for entrepreneurship education. Thus, the transfer to other fields requires further research and development.

Limitations

Methodologically, our results are limited in that the design process only derives requirements from literature and entrepreneurship education; besides, the user tests were only conducted with student participants (as the currently planned target group for PUMA). Here, an expansion of the user tests in scope as well as in number and heterogeneity as well as expertise of participants would be desirable and should additionally be operationalized quantitatively. We anticipate the potential for entrepreneurship practitioners as future users of the java application and we, therefore, encourage to look further into that.

However, the integration of the 55+ pattern cards needs to be clarified in terms of copyright for commercial usage.

Further limitations emerge technically since the PUMA requires local installation on a PC with Windows as the operating system and thus cannot be operated on IOS or Linux. Besides, an improvement in favor of a web application with responsive design could expand the circle of potential users, but licensing and copyright issues need to be investigated first. In terms of content, not all of the existing 60 BM patterns have been implemented at present. Therefore, we aim for their supplementation together with the embedding of further functionalities (e.g., storage and download function of the results). Another limitation is the restriction to analysis and ideation since PUMA currently does not support the actual implementation of adapted BMs. This could be the goal of a future research project.

Conclusion

The Java application PUMA, designed in three DSR iteration cycles, enables its users to first discover the inherent patterns of their BM and then to generate new ideas for adaptation in a divergent-convergent creativity process, in which the tool selects suitable BM patterns from 48 pattern cards stored in the backend. The artifact meant for entrepreneurship education purposes stimulates BM adaptation supported by guiding questions in a 6-phase process. PUMA thus makes the pattern-based adaptation of BMs tangible and also conveys the theoretical framework of Digital Darwinism with the resulting relevance of continuous adaptation for survival in the market.

We would like to suggest three concrete possibilities for future research avenues: First, PUMA could be further developed in the context of design-oriented research itself by integrating innovative technologies, such as AI-based analyzing and suggesting patterns for BMs or implementing a virtual tutor (e.g., voice or chatbot) that guides through the application (Maedche et al. 2019). Second, further research could focus on the impact of using the tool on learning motivation and success. Third, from a theoretical perspective, innovation processes could also be understood as pattern-based evolution in other contexts (e.g., biology, architecture, technology) and thereby, analogous to the already explored patterns of business models (Gassmann et al. 2014), also derive a repertoire of patterns that lead to innovation through novel combination. Further studies could extend the contents of PUMA, transfer it to new contexts, and validate it to anchor the potentials of pattern-based adaptation processes more firmly in education, science, and practice.

REFERENCES

Abdoun, A., and Ibrahim, J. 2018. “Business Model Canvas, the Lean Canvas and the Strategy Sketch: Comparison,” *International Journal of Scientific & Engineering Research* (9:1), p. 20.

Altshuller, G. 1999. *The Innovation Algorithm:TRIZ, Systematic Innovation and Technical Creativity*, (1st Edition.), Worcester, Mass: Technical Innovation Ctr.

Altshuller, G., and Williams, A. 1984. *Creativity as an Exact Science: The Theory of the Solution of Inventive Problems*, New York: Gordon and Breach Science Publishers.

Ashby, W. R. 1956. *An Introduction to Cybernetics*, Springer US.

Chawinga, W. D. 2017. “Taking Social Media to a University Classroom: Teaching and Learning Using Twitter and Blogs,” *International Journal of Educational Technology in Higher Education* (14:1), Springer, pp. 1–19.

Croitoru, A. 2017. “Schumpeter, Joseph Alois, 1939, Business Cycles: A Theoretical, Historical, and Statistical Analysis of the Capitalist Process,” *Journal of Comparative Research in Anthropology and Sociology* (8), pp. 67–80.

Csik, M. 2014. *Muster und das Generieren von Ideen für Geschäftsmodellinnovationen*, Dissertation of the University of St. Gallen.

Downs, J., and Velamuri, V. 2018. “Business Model Innovation in a Knowledge Revolution: An Evolutionary Theory Perspective,” *Managerial and Decision Economics* (39), pp. 550–562. (https://doi.org/10.1002/mde.2926).

Dzhukha, V. 2021. *Major Trends in Business Transformation in The Epoch of Digitalization*, Proceedings of the International Scientific Congress on Knowledge, Man and Civilization (107:1), Russia, pp. 425–433. (https://doi.org/10.15405/epsbs.2021.05.57).

Gassmann, O., Csik, M., and Frankenberger, K. 2014. *The Business Model Navigator: 55 Models That Will Revolutionise Your Business*, (1st ed.), Harlow, England; New York: FT Press.

Hameed, I., and Irfan, Z. 2019. "Entrepreneurship Education: A Review of Challenges, Characteristics and Opportunities," *Entrepreneurship Education* (2:3), pp. 135–148. (https://doi.org/10.1007/s41959-019-00018-z).

Hevner, A. 2007. "A Three Cycle View of Design Science Research," *Scandinavian Journal of Information Systems* (19:2), pp. 87–92.

Hevner, A. R., March, S. T., Park, J., and Ram, S. 2004. "Design Science in Information Systems Research," *MIS Quarterly* (28:1), pp. 75–105.

Kreutzer, R. T., and Land, K.-H. 2015. *Digital Darwinism: Branding and Business Models in Jeopardy*, Copernicus, Berlin Heidelberg: Springer-Verlag. (https://doi.org/10.1007/978-3-642-54401-9).

Lubart, T. 2016. "Creativity and Convergent Thinking: Reflections, Connections and Practical Considerations.," *RUDN Journal of Psychology and Pedagogics*, pp. 7–15. (https://doi.org/10.22363/2313-1683-2016-4-7-15).

Luhmann, N. 2012. *Introduction to Systems Theory*, Wiley.

Lv, Y., Chen, Y., Sha, Y., Wang, J., An, L., Chen, T., Huang, X., Huang, Y., and Huang, L. 2021. "How Entrepreneurship Education at Universities Influences Entrepreneurial Intention: Mediating Effect Based on Entrepreneurial Competence," *Frontiers in Psychology* (12).

Maedche, A., Legner, C., Benlian, A., Berger, B., Gimpel, H., Hess, T., Hinz, O., Morana, S., and Söllner, M. 2019. "AI-Based Digital Assistants," *Bus. Inf. Syst. Eng.* (https://doi.org/10.1007/s12599-019-00600-8).

Mandel, R., and Noyes, E. 2016. "Survey of Experiential Entrepreneurship Education Offerings among Top Undergraduate Entrepreneurship Programs," *Education+ Training*, Emerald Group Publishing Limited.

Mast, C. 2017. *Neuerfindung einer Industrie*, Springer Professional, Heidelberg.

Otache, I. 2019. "Entrepreneurship Education and Undergraduate Students' Self- and Paid-Employment Intentions: A Conceptual Framework," *Education & Training* (61:1), United Kingdom: Emerald Publishing, pp. 46–64. (https://doi.org/10.1108/ET-10-2017-0148).

Pettersson, F. 2021. "Understanding Digitalization and Educational Change in School by Means of Activity Theory and the Levels of Learning Concept," *Education and Information Technologies* (26:1), pp. 187–204. (https://doi.org/10.1007/s10639-020-10239-8).

Ratten, V., and Usmanij, P. 2021. "Entrepreneurship Education: Time for a Change in Research Direction?," *The International Journal of Management Education* (19:1), p. 100367. (https://doi.org/10.1016/j.ijme.2020.100367).

Razumnikova, O. M. 2013. "Divergent Versus Convergent Thinking," in *Encyclopedia of Creativity, Invention, Innovation and Entrepreneurship*, E. G. Carayannis (ed.), New York, NY: Springer, pp. 546–552. (https://doi.org/10.1007/978-1-4614-3858-8_362).

Runco, M. A. 2013. "Divergent Thinking," in *Encyclopedia of Creativity, Invention, Innovation and Entrepreneurship*, E. G. Carayannis (ed.), New York, NY: Springer, pp. 542–546. (https://doi.org/10.1007/978-1-4614-3858-8_430).

Schlimbach, R. 2020. "Geschäftsmodellinnovation im Kontext des Digitalen Darwinismus - ein evolutorischer Erklärungsansatz," Kiel, Hamburg: ZBW – Leibniz Information Centre for Economics. (http://hdl.handle.net/10419/218746, accessed April 25, 2022).

Schlimbach, R. 2021. "Geschäftsmodellinnovation im Kontext des Digitalen Darwinismus: Konzeption und Evaluation eines evolutorischen Frameworks," TU Braunschweig. (10.24355/dbbs.084-202103100859-0).

Schlimbach, R., and Robra-Bissantz, S. 2022. *Adapt or Die! - A Board Game to Support Dynamic Business Model Creation in Digital Darwinism*, Proceedings of the 15th International Conference on Information Systems (WI22), Nürnberg, Germany.

Schrader, M. 2017. *Transformational Products: The Code behind Digital Products That Are Shaping Our Lives and Revolutionizing Our Economies*, (1st edition.), Hamburg: Next Factory Ottensen.

Someren, M., Barnard, Y., and Sandberg, J. 1994. *The Think Aloud Method - A Practical Guide to Modelling Cognitive Processes*, Academic Press of the University of Amsterdam.

Souchkov, V. 2007. *Breakthrough Thinking with TRIZ for Business and Management: An Overview*, (ICG Training&Consulting).

Troise, C., Corvello, V., Ghobadian, A., and O'Regan, N. 2022. "How Can SMEs Successfully Navigate VUCA Environment: The Role of Agility in the Digital Transformation Era," *Technological Forecasting and Social Change* (174). (https://doi.org/10.1016/j.techfore.2021.121227).