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Implementation in Design-Based Research Projects: A Map of Implementation Typologies and Strategies

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Abstract

Design-based research (DBR) boldly claims to contribute to developing theory and practice through design experiments, but little is reported on how to make those contributions impact beyond project foci. This article provides a scoping review on current DBR literature that shows this to be a current and persistent problem, necessitating research on how to better implement DBR outcomes to expand impact. A two-dimensional model is employed for categorising review findings on implementation, with emphasis on efforts towards 1) timeframe and budget, and 2) context and stakeholders. These dimensions each employ a within-beyond distinction, to address the orientation of the implementation efforts. Findings include the identification of three implementation strategies beyond the project, and one non-strategy: sustained implementation, expansive implementation, adaptive implementation, and no implementation beyond project foci. Further, we identify projects in the intersections between the two dimensions. Together, these findings contribute to a map of DBR implementation typologies and strategies for improving the impact of future DBR projects.

Keywords

Design-based research, educational research, implementation strategy, sustainability, digital technology

Introduction

“An effective intervention should be able to migrate from our experimental classroom to average classrooms operated by and for average students and teachers, supported by realistic technology”, (Brown, 1992, p. 143).

Brown encourages implementation efforts for migrating results and interventions out of the artificial conditions of design-based research (DBR) experiments and making them more available. Anderson and Shattuck (2012) note the importance of developing design principles to prevent classroom benefits from disappearing once the experiment has been concluded. DBR aspires to change results through theories, practices, and artifacts that can be generalised to other schools and classrooms (Barab, 2014).

The understanding of the implementation process varies significantly across DBR. Reviewing DBR literature regarding, for example, when implementation takes place in the process as a whole, we see differences: implementation is considered to be part of the design process (e.g., Kelly et al., 2018; Parmaxi & Zaphiris, 2019; Trimmer, 2020, Wang & Hannafin, 2005; Zydney et al., 2020), an effort made after the design process (e.g., Birt & Cowling, 2018;

Reeves, 2006), the overall purpose of the process (e.g., Biase, 2019; Dunn et al., 2019; Ji & Pham, 2020; Ozverir et al., 2017), or combinations thereof (e.g., Turucz et al., 2021). The term is often associated with conducting experiments within the project and subsequent diffusion beyond the project. Amiel and Reeves (2008, p. 35) describe how “new designs are created and implemented, producing a continuous cycle of design-reflection-design” as part of their model, but also subsequent diffusion as the outcome of design-based research are a set of design principles or guidelines derived empirically and richly described, which can be implemented by other interested in studying similar settings and concerns.

The term implementation often covers both (Turucz et al., 2021), or merely the execution of plans (Kelly et al., 2019). Wang and Hannafin (2005) describe how project collaborators seek to improve an initial design through implementation, making it part of an iterative design process. Similarly, Birt and Cowling (2018) emphasise implementation as iterative, as each design iteration is implemented in practice. Jesson and Parr (2019) offer more clarification by distinguishing between implementation as trialling refined instructional designs, and efforts to sustain effects over time. Consequently, we argue that sustainability implies interventions that stick to the practices they are implemented into, and remain integrated over time.

The lack of scientific maturity in DBR has previously been addressed by McKenney and Reeves (2013), as many projects reported that they were finetuning designs under favourable circumstances. Leonard et al. (2016) note that much DBR literature reports on potential contributions rather than actual impact. This calls for maturation of reported research that currently reports extensively on applied technology and pilot testing (Tho & Yeung, 2016) and potential in educational settings (Karagozlu et al., 2017), but lacks emphasis on impact, design principles, and implementation, while Oh and Huang (2018) portray DBR as a fragmented field. Such limitations can be attributed to grant policies emphasising early DBR stage activities and piloting particular emerging technologies over implementation and diffusion or, as noted by Trimmer (2020), because outcomes fail to emerge during a short project span. Beckmann and Mahanty (2016) notice how funding, legal, and logistical constraints can impede development and subsequent operation.

In summary, we see that within the DBR cited, implementation is vaguely defined and reported impact is limited. To strengthen the impact of DBR projects in education this article asks: *How might we support reflection on and development of DBR implementation strategies?* To answer this, we review current DBR literature on how implementation is described. We first present our review strategy and then a within-beyond model, which we use for analysing and presenting these findings. Through this mapping, we ask how researchers might contribute to accentuating and strategically supporting future DBR implementation and the impact of such efforts.

Method: Scoping review

A scoping review is conducted to explore implementation efforts in current educational DBR literature. The scoping review is a topic-based literature search informed by an a priori protocol; it has an explicit, transparent, peer reviewed search strategy; and data is extracted into standardised forms (Munn et al., 2018). Scoping reviews are ideal for examining what literature covers a given topic and can provide clear indication of the amount of available literature and an overview of its focus (Munn et al., 2018), as well as contributing to synthesising evidence.

To distinguish between DBR projects versus sources merely mentioning DBR, our search strategy combines search words with index search, utilising database provider indexing to

focus specifically on projects characterised as DBR in education. While this reduces search sensitivity by being less inclusive (compared to, for example, Google Scholar), it increases specificity by eliminating cases merely mentioning DBR or education. Designating papers as a specific study type contributes to improving retrieval sensitivity and precision (Haynes et al., 2005), and can contribute to improving retrieval performance (Wilczynski & Haynes, 2009), through professional indexing capacities, using controlled vocabularies and rigorous index terms to improve completeness and accuracy of search results (Koolen, 2014). This offers a systemised alternative to headline and abstract scanning. To improve sensitivity, Aalborg University's database host, PRIMO, was utilised to combine results across database providers (including ERIC, ProQuest, and Scopus), using various spellings of DBR. To improve specificity, searches were limited to publications with an educational focus in peer-reviewed journals for the past five years (2016-2021) to focus on the recent development in DBR. The resulting 36 sources were reviewed considering project implementation.

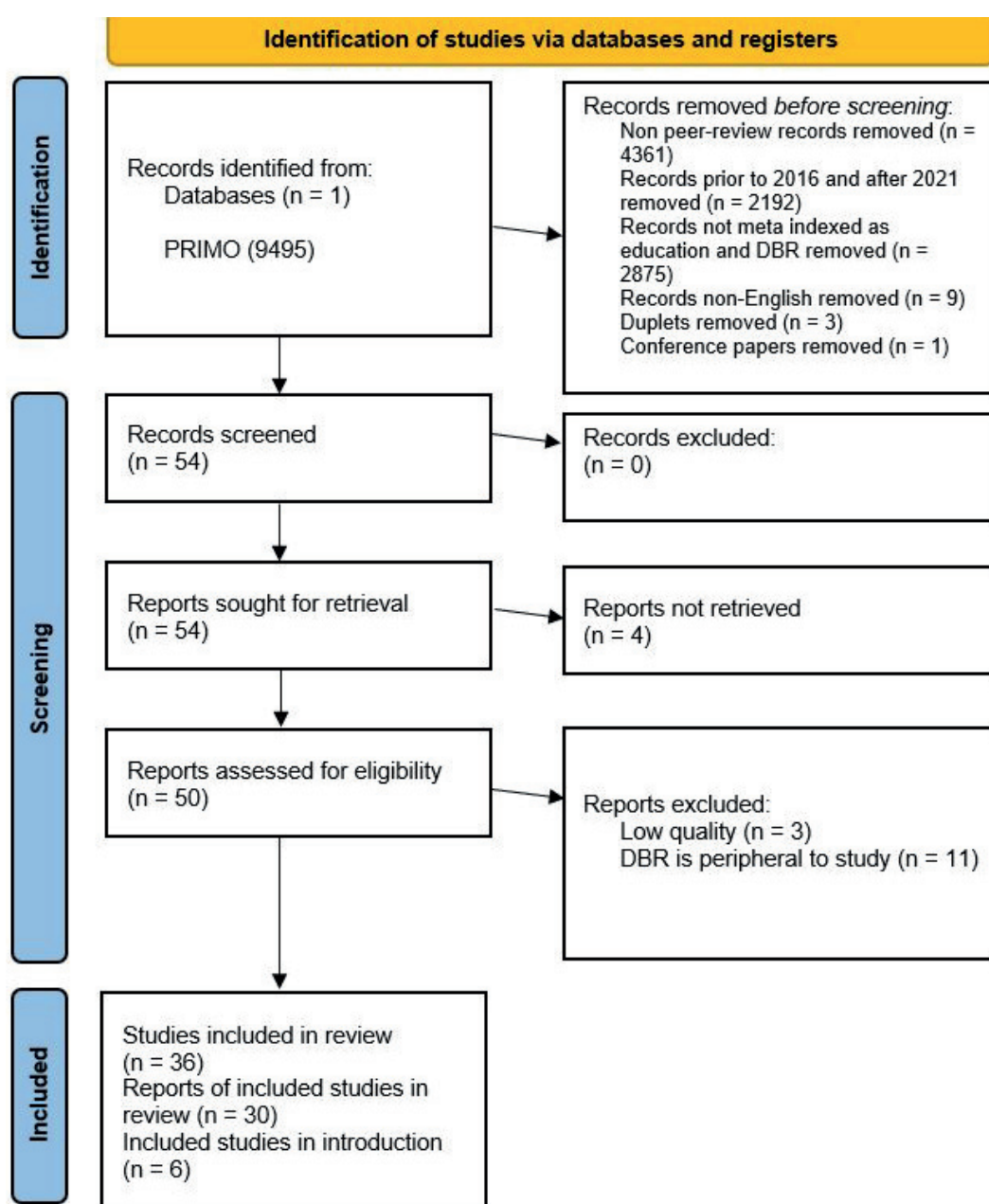


Figure 1 Prisma flow chart

Scoping Review: Implementation Strategies in DBR

The review reveals several implementation strategies that are presented below and subsequently mapped into the within-beyond implementation model.

Theoretical lens: A within-beyond model on implementation

The two-dimensional project sustainability model (PSM) is used to assess how DBR implementation efforts expand the original project (see Figure 2). Based on Mikkelsen and Riis (2003), the PSM emphasises the temporal and proximal nature of projects, using a within-beyond distinction to describe the scope and directedness of implementation efforts, and has previously been used for evaluating the implementation efforts of Danish school development projects (Henriksen, et al., 2011). The scoping review uses the model to assess the implementation efforts described in current DBR to map out strategies and principles for better implementation.

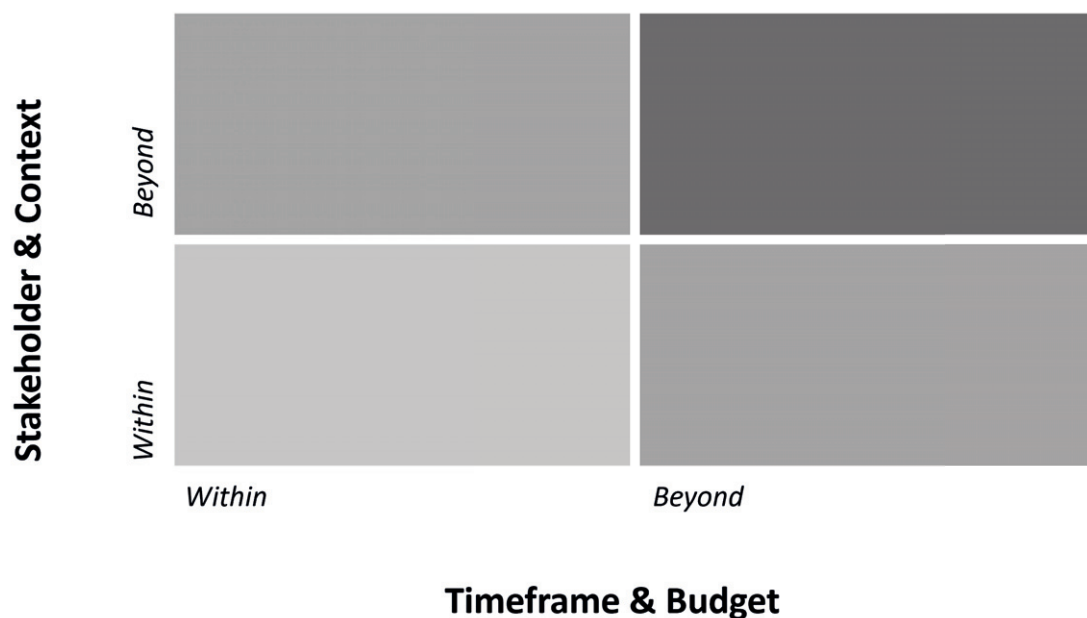


Figure 2 The within-beyond implementation model. This figure illustrates how the two dimensions produce four intersections and thereby four strategies for implementation beyond project foci.

Dimension 1: Time & budget

This first dimension addresses implementation as aimed within or beyond project period and budget. This reflects how the term is both used *during the iterative process* for integrating interventions into the experimental context, and *subsequently* for turning them into sustainable transformation. *Within* efforts cover integrating a design as an intervention into the context, while trying to improve a process within the project timeframe and budget. Such efforts aim to inform the iterative design process, by providing concrete experiences of using a designed intervention. Such an understanding of implementation might rely on an expectation that significant improvements have lasting effects, thereby becoming self-sustainable. *Beyond* efforts emphasise the subsequent life of an intervention, aiming to expand this beyond a project's time or budget limitations, by making them sustainable. This recognises interventions as temporal, and without a catalysing effect, for example, through the

development of didactic frameworks, teachers' professional development (PD) or organisational support, interventions and effects will run out. As an example, the providing change through a mere purchase and handover of laptops to students would end as a new set had to be provided to the next set of students, whereas the development of didactics for employing interactive whiteboards would expand beyond the project, as they can be used even when the whiteboards age.

Dimension 2: Project stakeholders and context

The second dimension addresses implementation as aimed within or beyond the project group and a specific context. This distinction reflects the target group of the implementation, emphasising either those taking part in design and test iterations or an audience beyond that group. *Within* efforts concern the engagement of project participants into DBR processes. This participatory approach reflects the co-opting on defining problems, building solutions, and practitioner involvement often seen in action research programmes. *Beyond* efforts emphasise the development of interventions and communication to someone not part of the process but expected to benefit. This approach to implementation is often seen in planned organisational change (Boonstra, 2004) and policy implementation. As an example, a project group would use a DBR process to develop a solution to one classroom that subsequently would be implemented among the rest of the staff and other classrooms.

The two-dimensional distinction between orientation *within* or *beyond* serves as a guide to review the various understandings of implementation and implementation strategy in current DBR reports.

DBR implementation typologies from review

Sustained implementation

First, we look at implementation that aims to secure impact on the participating individuals and institutions beyond project termination. Attention towards sustainability stems from Fowler and Leonard (2021), who notice how mathematics teaching habits are highly resistant to change and, to make changes sustainable, an intervention must break with habit. These studies are seen in contrast to the widespread reporting from pilot studies (Tho & Yeung, 2016) that focus on producing effects within projects. Our scoping review indicates various approaches to such sustained implementation, as the approaches aim to sustain the project in context with the participating stakeholder, but beyond time and budget.

Sustained implementation through ambassadors

One strategy is to sustain the project and impact through ambassadors or passionate participants that carry on the methods and ideas through their practice. Dunn et al. (2019) address sustained implementation by concluding that ongoing DBR participation may contribute to improving teachers' institutional practice through a sustained effort, and Huijboom et al. (2020) involves teachers in early-stage design to promote sustainable impact. To promote large-scale implementation beyond the original project, Zeggelaar et al. (2020) establish design requirements for a PD programme. Easterday et al. (2016) emphasise "last phase presentation" to communicate "to key stakeholders why the design will better solve a problem that addresses their interests [and] to ensure appropriate support for the project" (p. 127). This involves creating presentations, research papers, and grant proposals to further sustain the project and its impact. Thus, they suggest implementation, through providing the pedagogical staff with arguments for the design, but they also suggest institutionalisation of the project.

Sustainable implementation through institutionalisation

Institutionalisation of developed practices offers an approach to expanding project impact that relates to the Timeframe and Budget dimension. Langendyk et al. (2016) describes DBR over a three-year period as a framework for continuously developing a medical school curriculum, integrating community and transformative learning principles, and addressing a hidden curriculum. Hesterman (2016) uses DBR to integrate online learning activities in higher education, using annual iterations to deal with emerging problems. In developing student-centred and social-media-based learning environments for journalism students, Narayan et al. (2019) develop principles for employing learner-owned, open-platform independent technologies to facilitate sustainability.

Expansive implementation

The review reveals limited emphasis on how designs and findings are diffused to involve stakeholders and contexts beyond the original project. Two kinds of efforts are seen: design diffusion, which disperses ideas and methods by reifying them into solutions among relevant parties, and PD efforts to introduce practitioners to the innovation.

Design diffusion

Implementation strategies based on design diffusion may utilise passive or active approaches relying on designs that inhabit the ideas and methods developed through a DBR project, and have different approaches to stakeholders and contexts.

Passive diffusion involves making a design available for use as, for example, a framework for solving real-world problems through mathematics (Geiger et al., 2018), a template for online collaboration (Hesterman, 2016), or as design principles (e.g., Ozverir et al., 2017). Passive diffusion makes materials and guidelines available to pull-based diffusion, relying on producing designs that convey project ideas and methods, without explicitly addressing future end users and contexts. According to Fahd et al. (2021), the expectation that interventions will migrate from one context to another is a limitation to current DBR practice.

Pure active diffusion did not emerge in the review, but would involve purposeful, push-based communication of designs to future users. A *combined approach* is reported by Kelly et al. (2018), who present TeachConnect as a service that meets an ongoing concern among pre-service teachers, while actively promoting its service. By addressing a pressing issue among pre-service teachers by word-of-mouth, and actively communicating the service through face-to-face sessions, it combined an active push with passive pull for successful recruitment. Jackson-Barrett et al. (2019) supplement their implementation communiqué with guidelines for better future implementation with project-external stakeholders.

Implementation through PD for future users

Another strategy within expansive implementation is PD that relies on stakeholders' competencies to transpose DBR innovations. Reviewed literature presents PD as an effective strategy to allow DBR innovations to address a broad audience.

Training provides a smooth transition when implementing new technology (Ozverir et al., 2017), and dealing with situated, practical complexity is a significant factor when considering the efforts required by teachers to change their practice (Biase, 2019). Teachers must be motivated to do so, especially in policy implementation and other imposed change (Schweisfurth, 2015). Huijboom et al. (2020) notice how involving teachers in early design stages improves chances of creating lasting change in education, providing an active role as joint developer and learner rather than as recipient. Despite the benefits of an involv-

ing approach to facilitating PD, such approaches to qualifying development still resist widespread implementation (Kelly et al., 2019). Leonard and Fitzgerald (2018) notice how ongoing technical concern, perceived lack of control in technology-rich environments, and managerial limitations, impede subsequent implementation.

PD is often a primary mechanism to build teacher capacity to attain higher levels of student achievement (Dunn et al., 2019), and a prerequisite when implementing policy to local conditions. Frameworks for making a project's ideas and methods available to future users through PD is diffused through passive means, without actively addressing specific target groups or contexts, for example, Kelly et al. (2019), who propose a curriculum planning design for PD through co-design, which they believe has system-wide potential. In contrast, TeachConnect employs a dynamic diffusion strategy for making their platform available, using a word-of-mouth approach to establishing it as the default go-to place for pre-service teachers, and face-to-face presentations as part of PD efforts (Kelly, 2018).

Adaptive implementation

We have categorised a body of reviewed studies as adaptive implementation, which combines sustained with expansive implementation strategies to adapt and iterate the ideas and methods developed in the project beyond its timeframe and budget, but also disperses them to new stakeholders and contexts.

In this review, this strategy is encountered, for instance, when facilitating PD and implementing curriculum requirements through iterative processing (Glasswell et al., 2016; Wilkie, 2016), transitioning from face-to-face to online teaching (Davey et al., 2019), during new subject implementation (Kelly et al., 2019), implementing common core standards (Dunn et al. 2019), and transitioning to task-based language teaching and implementing a particular pedagogical approach (Ji & Pham, 2020). Biase (2019) describes how a localised DBR process is used for implementing government policy, shifting its emphasis from *what* to *how*, noting this as significant when considering the effort required by teachers to change their practice. Such projects differ from the action-research-inspired approach to co-designing associated with DBR, as the iterations here concern teachers' adaptation, and not design participation.

Adaptive use of DBR implementation strategies is also seen in projects that already have a technological solution to be implemented, using DBR cycles to refine integration. Dousay and Weible (2019) investigate how 3D pens might be used in science education, Wilkie and Clarke (2016) use DBR to explore and develop visualisation techniques for working with a particular problem within mathematics education, and Jackson-Barrett et al. (2019) explore the use of technology in potential educational roles. Dunn et al. (2019) describe how the iterative element of DBR facilitates adaptation, when implementing common core state standards to develop students' understanding of mathematics. Rather than the usual one-off workshop-based take on teachers' PD, the iterative process contributed to embedding itself into participant practice, and significantly impacted teacher practice.

Institutionalisation allows projects to expand beyond their original time frame, and integrate with future stakeholders and contexts, through designs that reify the ideas and methods that are developed within the project, but may also be adapted beyond. Institutionalisation also allows diffusion and implementation principles to be tested and adapted, as seen with Kelly et al. (2019), who tested and adapted their framework for co-designing curriculum planning in a new context, as part of the frameworks implementation efforts. An ultimate test of design is seen with Miranda et al. (2020), who describe the commercial launch and marketing of a simulation device to train nurses in installing intravenous access as a DBR outcome.

In terms of frameworks and abstract constructs, several authors report the development of design principles that communicate contextualised findings in a generalised form. Other projects use abstract conceptual frameworks for adaptive implementation, for example, for policy implementation (Biase, 2019), implementing particular pedagogical approaches (Ji & Pham, 2020), common core state standards (Dunn et al., 2019), a framework for continuously improving a medical school curriculum (Langendyk et al., 2016), journalism syllabus activities (Narayan et al., 2019), curriculum planning (Kelly et al., 2019), or new curriculum requirements (Glasswell et al., 2016; Wilkie, 2016).

Others provide concrete conceptual frameworks to facilitate implementation in new contexts as a supplement to the technological implementation, this happened with, for example, the development of effective PD (Zeggelaar, et al., 2020), blended learning (Zydney et al., 2020), the flipped classroom (Zhao et al., 2021), visualisation techniques in mathematics (Wilkie & Clarke, 2016), templates for bringing real-world problems into the classroom (Geiger et al., 2018), using technology to build student-centred learning environments (Narayan et al., 2019), and transitioning from face-to-face to online teaching (Davey et al., 2019). In terms of concrete constructs, authors describe the development of technological products and institutional procedure as means for expanding impact beyond the original project. Examples include a framework for continuously improving a medical school curriculum (Langendyk et al., 2016), journalist education syllabi activities (Narayan et al., 2019), curriculum planning (Kelly et al., 2019), the development a marketable medical simulation device (Miranda et al., 2020), and online platforms for facilitating PD (Kelly et al., 2018).

Discussion and findings

Through a mapping of 36 recent papers on DBR in educational contexts, we have shown three main types of implementations that depict the contours of a map of DBR implementation typologies and strategies. These are illustrated in Figure 3. In Figure 4, we have added the six strategies highlighted through analysis of the papers, employed either individually or in concert. The examples provided through the review encompass changing the organisational setup, establishing communities of practice, nurturing the competence of individuals, and developing constructs that support practice. These are examples of strategies, and we imagine that there are more that could be added to the map. Through this map, we wish to contribute to reflections on implementations of DBR projects that move beyond the projects themselves. DBR researchers may use the map when considering what types of strategies they apply when designing a DBR project. Are they, for example, providing participants with organisational changes, and nurturing a community of practices at the organisations to *sustain* the change in the context beyond deadline? Is project *expansion* facilitated by *active* and deliberate efforts to present and communicate findings to new actors or stakeholders, or does it rely on *passive* means of making materials available for other to inquire into? Does a design develop what McKenny and Reeves (2012) describe as *a life of its own* with new stakeholders in new contexts after project termination? Are organisational setups changed, and constructs implemented, to support such new practices?

The strategies described in both the *expansive* and *sustained* typologies of implementation contain a *push* or *pull* dimension. Push implies a strategy that intentionally presents and diffuses the innovation to new participants. The push strategy is utilised in Miranda's (2020) DBR project-adaptive implementation strategy, in which a medical simulation is developed and marketed to stakeholders. Pull implies a strategy that deliberately offers the innovation to whoever might stumble upon it when they need it. The real-world mathematics problem

template developed and made available by Geiger et al. (2018) for others to pick up and use is an example of an expansive pull strategy. A powerful combination is found in projects that succeed in involving participants at an early stage, allowing them to contribute by providing the process with a problem relevant to their practice, thereby resulting in a participatory, demand-driven implementation.

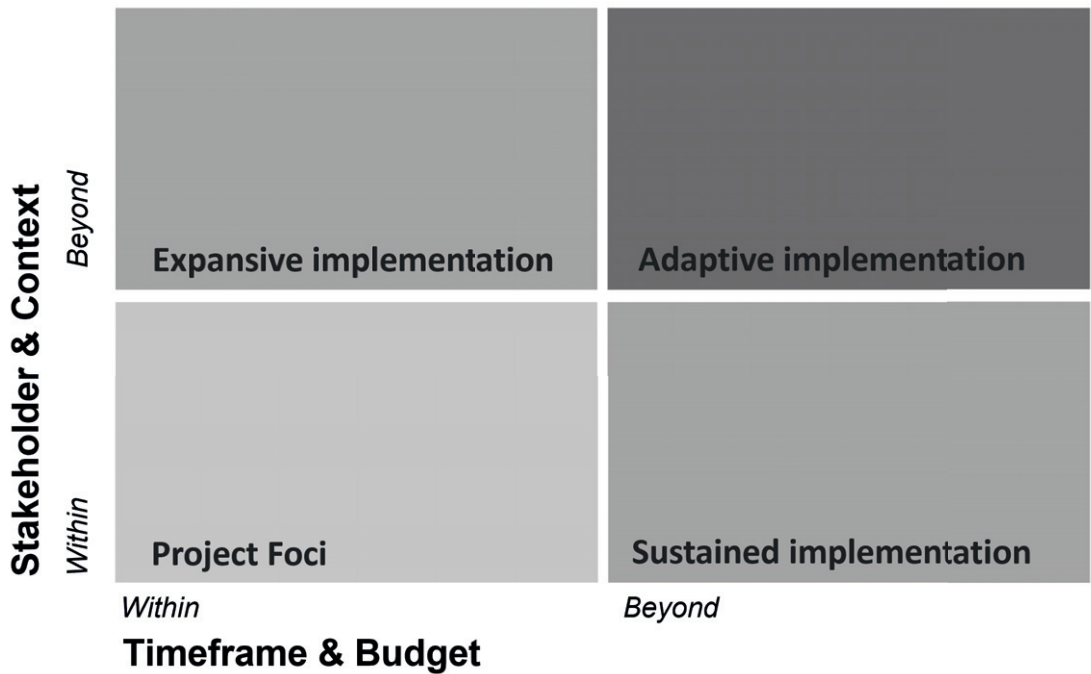


Figure 3 Map of DBR implementation typologies.

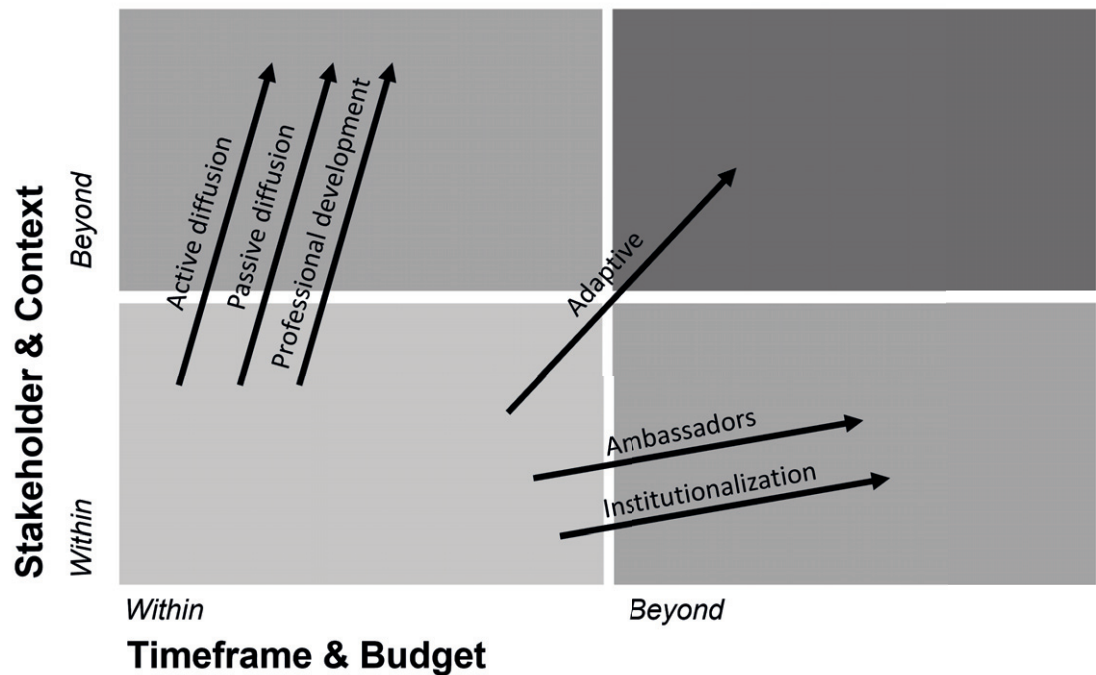


Figure 4 Map of DBR implementation strategies.

As the review shows, details on how to expand implementation are scarce. Little emphasis was found on dealing with sustaining or diffusing DBR outcomes beyond the original project and context. In Table 1, we exemplify the intersections between the three forms of implementation (sustained, expansive, and adaptive) strategies through four of the reviewed studies.

Table 1 Intersections between implementation typologies

Time & Budget	Stakeholders & Context	Examples of DBR projects from the reviewed papers
<i>No explicit implementation beyond the project</i>		
Within	Within	Matruglio (2019) illustrates a project that emphasises how a select project group works with a particular problem within context and time frame, which results in a situated solution.
<i>Sustained implementation</i>		
Beyond	Within	Narayan et al. (2019) illustrate how design principles for employing learner-owned, open, platform-independent technologies can facilitate sustainability through institutionalisation.
<i>Expansive implementation</i>		
Within	Beyond	Geiger et al. (2018) make a template available for solving real-world problems through mathematics for others to pick up and use.
<i>Adaptive implementation</i>		
Beyond	Beyond	Miranda (2020) describes the iterative development of a medical simulation, which is put into production and marketed to stakeholders, to whom it affords implementation into their teaching practice.

The intersections provide important alternatives to a diffusion strategy, based on design principles found in classical DBR literature, to make an impact beyond the contextualised problem. The review proposes several strategies for expanding the impact (Table 2).

Table 2 Suggested strategies for expanding Impact

<i>Project foci</i>	Exclusive focus on meeting project objectives within the defined scope.
<i>Sustained implementation</i>	Nurture ambassadors or institutionalise findings to expand beyond the project frame.
<i>Expansive implementation</i>	Provide presentations, designs, or training efforts to provide opportunity for others to implement the solution in new contexts.
<i>Adaptive implementation</i>	Provision of design principles and guidelines to assist stakeholders in generating DBR in new contexts, and/or providing solutions that afford stakeholders to either adopt the solution or its principles and initiate a new DBR process.

The findings necessitate a discussion on how DBR outcomes are expected to impact beyond project time frame, budget, stakeholders, and context. Given the contextualised nature of DBR, presuming that solutions can be implemented in other contexts does present a

paradox. This paradox also extends to diffusing solutions to other stakeholders beyond the project, as it conflicts with DBR's participatory and often action-based approach. The adaptive approach proposes a solution, as it seeks to afford the initiation of new DBR processes, either by providing abstract constructs for framing technology usage or concrete constructs to be framed into new contexts or timelines.

Conclusion

This article set out to study how implementation efforts can contribute to amplifying DBR impact beyond the restrained conditions of DBR experiments, while making sure that findings and impact remain once the process has been concluded. By scoping and categorising the literature on DBR and implementation into the DBR Implementation Map, we see that the implementation strategies used are a mix of changing the organisational setup, establishing communities of practice, nurturing the competence of individuals, and developing constructs that support practice. While the model contributes to identifying and reflecting implementation efforts, we argue that the deliberate application of implementation strategies may contribute to securing the impact of DBR, both in terms of sustaining, expanding, or adapting its effects beyond the original project. While the development and employment of such strategies should be seen in context, we hope the typology offered by the DBR Implementation Map will contribute to sustaining, diffusing, and expanding the impact of future DBR projects.

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