EDeR

Educational Design Research

Volume 9 | Issue 2 | 2025 | Article 65

Contribution Academic Article

Title Towards a Model for Characterizing Instruments Used in Design-Based Research

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Abstract The aim of this paper is to characterize and discuss the features of instruments that might be useful to carry out design-based research (DBR). DBR is a methodology for conducting scientific research in real educational settings. DBR aims to bridge the gap between theory and practice by involving practitioners through the iterative and collaborative development and analysis of technology-enhanced learning environments. As DBR is an emerging

and fast-growing methodology, we note the importance of documenting and formalizing the various instruments used by researchers. Our methodological approach involves a categorical content analysis of survey data and workshop minutes to identify nine descriptive criteria for DBR instruments. These criteria cover various aspects such as artifact description, legal notices, theoretical foundation, temporality, limits and difficulties, example of use, prescribers or beneficiaries, contact person, and needs of DBR. The findings reveal that the criteria can be categorized into three groups: artifact characteristics, actors using the instrument, and patterns of instrument use. The contribution of this research lies in providing a comprehensive model for describing and analyzing DBR instruments, highlighting the need for documenting and updating of instruments based on usage patterns and DBR needs.

Keywords Design-based research, Instruments modelization, Pattern of use, Instrument's library, Collaborative research, Co-design

DOI The DOI will be added when the issue is published.

Citation Paukovics, E., Prior, E., Morard, S. & Sanchez, E. (2024). Towards a Model for Characterizing Instruments Used in Design-Based Research. *EDeR – Educational Design Research,* 8(2), 1-19.

The DOI will be added when the issue is published.

Towards a Model for Characterizing Instruments Used in Design-Based Research

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1.0 Introduction

Design-based research is a methodology for conducting collaborative research based on the design, development and evaluation of educational artifacts in real educational settings (Sanchez & Monod-Ansaldi, 2015; The Design-Based Research Collective, 2003; Wang & Hannafin, 2005). Since 2015, the researchers from the Laboratory of pedagogical Innovation of the University of Geneva (LIP, https://www.lip-unige.ch) carry out design-based research (DBR) on different topics in various educational settings (e.g. game-based learning for museum school visits, health education and computational thinking, learning labs and digital innovation for higher education, online teaching and learning…) (Morard & Sanchez, 2021; Sanchez et al., 2021). The Lab conducts different DBR projects in parallel. Most of them are supported by national funds or non-profit corporations such as foundations. In this context, three PhD research projects are being conducted on the study of the epistemological and methodological foundations of DBR (Paukovics, 2023; Prior, 2021).

The multiplicity of projects and the hiring of new collaborators have revealed the need to inventory and organize the instrument to conduct DBR (e.g. tools or activities used by actors in a specific situation to answer a need). Indeed, collaborators create tools, activities, methods from scratch, allowing them to advance in their research process without realizing that they could be useful for the other members of the lab. A working group was created to develop a space for describing and sharing instruments (e.g. interactive instruments library). This first need was quickly put in parallel with a lack of literature on the issue of instruments mobilized and developed to support research and design activities in DBR. This observation led us to launch a study aimed at characterizing what an instrument is in the context of DBR. Our objective is not to present all the instruments used, but rather to understand what characterizes them from a DBR perspective. The aim of this article is therefore twofold: (1) to propose a theoretical model of instruments and to present how we create it while developing a database of the instruments used, and (2) to identify common criteria for characterizing instruments, their use in DBR and how the characteristics of the instruments correspond to the DBR's principles.

First, we describe the characteristics of DBR (Sanchez & Monod-Ansaldi, 2015; The Design-Based Research Collective, 2003), the principles to implement it (Wang & Hannafin, 2005) and some existing tools (instruments) to follow these principles (Mandran et al., 2022). We define our conception of "instruments" based on Rabardel's (1995) instrumental genesis, which leads us to favor the term "instrument" over "tool". Chapters 3 and 4 present in detail the research questions of this contribution as well as the method of data production and analysis. A first bottom-up analysis provides nine descriptive criteria. From this a modeling of the instruments is proposed in chapter 5. This modeling is finally discussed on the basis of the DBR principles in chapter 6.

2.0 Design-Based Research: Characteristics, Collaborative Nature, and Instruments

Design-based research (DBR) is an evolving methodology in the field of education (Cividatti et al., 2021; Tinoca et al., 2022). It originated from design experiments, which involve engineering innovative educational environments while conducting experimental studies on these innovations (Brown, 1992; Cobb et al., 2003). The Design-Based Research Collective laid the methodological foundations of DBR in 2003. DBR addresses the need for an improvement paradigm in education, acknowledging the complexity of educational work and the variability of outcomes (Bryk, 2015). It is considered an alternative to randomized field trials, which may not effectively inform relevant educational interventions in complex and ever-changing settings (Bryk, 2015). DBR relies on collaborative interventions conducted by researchers and practitioners, who jointly problematize educational issues, design technology-enhanced learning solutions, and analyze their effects (Anderson & Shattuck, 2010; The Design-Based Research Collective, 2003). To meet the requirements of DBR, specific instruments need to be constructed and mobilized.

DBR is characterized by five key elements (The Design-Based Research Collective, 2003). First, it aims to align educational objectives with research objectives. Second, it follows iterative cycles involving phases of analysis, design, and experimentation. Third, it emphasizes the sharing of results and effective communication between practitioners and researchers. Fourth, DBR produces complex and contextualized research outcomes, which are documented and empirically supported. Finally, DBR is collaborative, contributory, grounded, and iterative (Sanchez & Monod-Ansaldi, 2015).

DBR embraces a collaborative approach by considering practitioners as research partners (Desgagné et al., 2001). The partnership begins with the co-problematization phase, where researchers and practitioners collaborate to articulate field needs and theoretical objectives (Desgagné et al., 2001). DBR is contributory, requiring attention to the demands and problems of professionals to create applicable solutions (Lewin, 1946). Building trusting relationships and establishing a proac-

tive group dynamic are crucial. Effective knowledge sharing is essential, necessitating a "common background" between researchers and practitioners (Bednarz, 2013; Ligozat & Marlot, 2016; Paukovics, 2023). DBR is conducted in real educational settings, embracing the complexity of the studied contexts rather than reducing it (Barab & Squire, 2004; Tinoca et al., 2022). Contextual variables are considered integral to the phenomena under study (The Design-Based Research Collective, 2003). DBR follows an iterative process throughout all phases. It involves the evolutionary prototyping of an ideal educational intervention (Van den Akker, 1999) and continually refines research questions, hypotheses, and methods based on macrocycles and microcycles (Gravemeijer & Cobb, 2006). Pragmatic and heuristic goals are pursued in an agile and flexible manner.

Implementing DBR poses challenges due to the complexity of variables involved and the iterative nature of the research process (Barab & Squire, 2004). Wang and Hannafin (2005) address the implementation of DBR for researching digital educational technologies and propose nine principles: supporting design with research (p1), setting practical goals for theory development (p2), conducting research in representative real-world settings (p3), close collaboration with participants (p4), systematic and purposeful implementation of research methods (p5), immediate and continuous data analysis (p6), continual refinement of designs (p7), documenting contextual influences with design principles (p8), and validating the generalizability of the design (p9).

While many studies have explored the epistemological and methodological challenges of DBR, there is a need to address the organizational complexity of the process (Bachelard, 1984), in particular, the involvement of stakeholders and institutions in collaborative activities, the interdependence between scientific and practical objectives, the professional development of teachers and researchers, and the need for specific tools and techniques to study educational issues within DBR. Specific instruments are required to support and structure the collaborative work between teachers and researchers and to foster a common background. Establishing communities of practice with a strong culture of collaboration for educational research is vital (Olin & Ingerman, 2016; Wenger, 1999). Concrete tools should be designed to address practice problems and create educational artifacts based on this shared background. Therefore, there is a need to conceptualize and design instruments dedicated to conducting design-based research.

The instrumental theory provides a framework for studying research instruments. According to Rabardel (1995), an instrument consists of both a material or symbolic artifact (referred to as "the tool") and cognitive abilities (referred to as "knowledge and mental operations"). Rabardel argues that instruments are not pre-existing entities but are elaborated by users during their activities through a process called "instrumental genesis." This process involves two aspects: instrumentalization and instrumentation. Instrumentalization refers to the user's appropriation and transformation of the artifact to perform specific tasks, while instrumentation involves the development of specific schemes by the user. Instrumentation is the actor’s adaptation to the constraints of the artifact. Overall, the subject adapts to the con-

straints and possibilities offered by the artifact. These processes contribute to the emergence and evolution of instruments, with uses and purposes that may extend beyond the initial design.

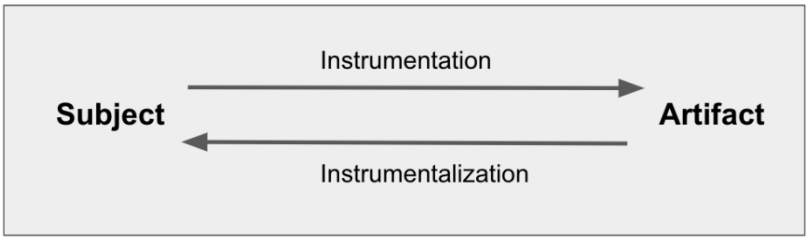

Figure 1: Instrumentation and instrumentalization process between subject and artifact (adapted from Trouche, 2005)

We have adopted the framework of instrumental genesis as a basis for examining the instruments used in DBR, as it allows us to consider the artifacts, the actors involved, and the patterns of use. In DBR, these instruments are designed by taking into account the context of use, the intended purposes, and how they are utilized by various actors. These actors include researchers, teachers, and other practitioners or end-users such as administrative staff, software developers, game designers, and even students.

In the field of DBR, specific instruments are sometimes adapted or borrowed from other methods or domains, such as THEDRE (Mandran, 2018), ADDIE (Branch, 2009), or meta-design (Fischer et al., 2004). THEDRE is a method of conducting research derived from supervising doctoral works in different disciplines and provides guides for conducting research in human-centered computing (Mandran, 2018). Although it supports a DBR-type research process, it does not fully address the way researchers appropriate research tools in terms of instrumentation. Similarly, ADDIE is a method that offers tools for designing and evaluating learning devices (Branch, 2009), but it does not consider the specific constraints and needs of researchers conducting DBR. Meta-design, on the other hand, focuses on creating socio-technical environments that empower end-users, including teachers, to actively participate in the design and continuous development of systems (Fischer et al.). While meta-design aligns with the objectives of DBR, the support provided by instruments for the participation of end-users, especially teachers, is still not well-referenced.

Overall, the utilization of instruments in DBR involves drawing from various existing works in educational research, instructional design, and teaching and learning engineering. However, the adaptation and integration of these instruments in the DBR context require careful consideration of the vocabulary, knowledge, and skills of the professional communities involved as in meta-design approach (Marne, 2014).

A Need to Characterize and Modelize DBR's Instruments

DBR has specific features that require the use of tailored instruments. In particular, the instrumentation of research should support collaboration for design, development and evaluation of educational interventions (Paukovics, 2022). However, the DBR instrumentalization is still in its infancy. Different instruments designed for similar purposes such as instructional design, UX design or meta-design might be used. We question their ability to meet specific DBR needs of the researchers involved in DBR. Such instruments are not well described in the literature but it does not mean that they do not exist. On the contrary, research teams conducting DBRs design ad hoc instruments or adapt existing methods or tools, particularly in order to considerate the specificities of the context studied, to facilitate collaboration, or to manage design and research iterations. For instance, Mission Télomère is an educational health prevention game created with a DBR approach (Morard & Sanchez, 2021). In this research, professionals from various disciplines (psychologists, educational researchers, game designers, healthcare trainers, teachers) collaborated on the design of the game. Several tools were used to facilitate the co-design as story cubes, persona and ideation forms. These tools come from different disciplines notably inspired by meta-design. We rely on Rabardel's (1995) instrumental genesis to investigate the patterns of use of these artifacts (as story cubes, ideation forms, persona forms) mobilised by the actors in a DBR.

Our work is based on the experience acquired during the implementation of about ten DBR projects in the Laboratory of pedagogical Innovation (LIP). Within the framework of these projects, many instruments have been designed or adapted to the needs of the research teams. We aim at characterizing and modeling these instruments. This objective is translated into two specific research questions:

What are the common criteria for characterizing instruments and their uses in DBR?

To what extent do these features allow these instruments to meet DBR's principles?

To answer these questions, we first identified the instruments designed, mobilized and used by the research teams to conduct DBR within the Laboratory and then examined the features of these instruments. We discuss these features regarding their ability to meet DBR needs: to facilitate collaborative work, design of realistic and adapted educational interventions, experimentations in real educational settings and allow for iterations needed to revise the designed interventions and/or research modalities.

4.0 Method: Data Production and Analysis

This research is itself inspired by DBR. To respond to a practical need, that of sharing the instruments used by researchers in the laboratory of pedagogical Innovation (LIP), we first designed an online and interactive digital instrument's library. This library takes the form of a data-

base, i.e a list of instruments described by different metadata providing information about the instrument concerned. A theoretical reference and the URL link to the text, for example, are part of the metadata. Another example of metadata is the name of the researcher who used and mentioned the instrument. This database may be updated by end-users. It was identified and described during workshops. The identification of the metadata was a first step towards the characterization of the instruments used in DBR. The description and categorization of the metadata then led to the characterization of the criteria presented in the model. The concrete development of the library is done in parallel with the creation of a theoretical model supporting the description of DBR instruments. Below, we describe and justify our research methodology according to the Narrative Design Method recommended by Hoadley (2004).

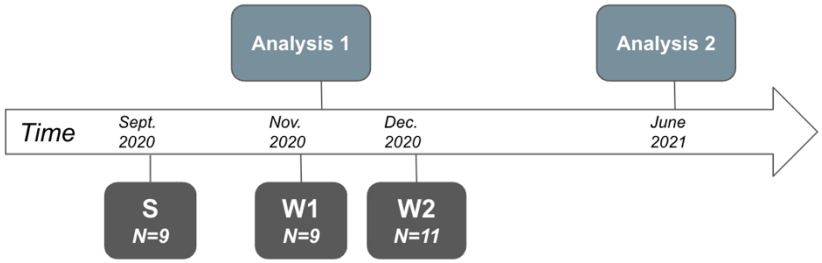

Figure 2: Timeline of data production and analysis

First, a survey (S) was created for the nine members of the lab conducting DBR (September 2020, Figure 2). This survey aimed at documenting: (1) five examples of tools used by these members who are researchers to conduct DBR, (2) their interest in pooling the resources they develop and use for design-based research. Based on the outcomes of the survey, we designed a first version of the DBR instrument's library (Figure 3). This library took the form of a database developed with Google Sheet.

A workshop (W1) was organized in November 2020 with the nine researchers who filled the survey. During this workshop, they were asked to complete and to update the first version of the library (v1) with all the instruments they used while they conduct DBR. After this workshop, the library had 49 instruments. The researchers were also asked to discuss the metadata of the database. On the basis of a categorical content analysis (Bardin, 2013; Krippendorff, 2018) the work resulted in an initial list of criteria for describing DBR instruments (Analysis 1). These criteria were discussed in relation to Rabardel's (1995) instrumental genesis. This discussion leads us to (i) adapt the database metadata producing a version 2 of the library and to (ii) describe and link the criteria together based on modeling. The criteria and the modeling of the instruments are presented as first results in chapter 5. The metadata of the database was modified according to the outcomes of this workshop and the first version of the library was revised.

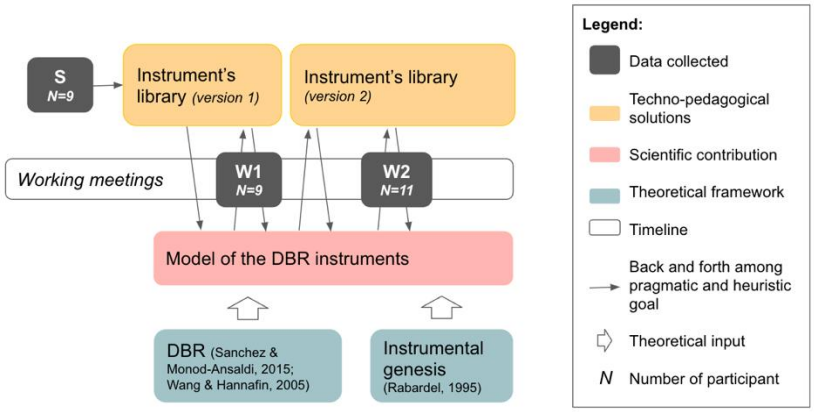

Figure 3: Diagram of the research methodology

A second workshop was held in December 2020 with 11 researchers. The purpose of this workshop was to discuss the second version of the library according to the DBR principles proposed by Wang & Hannafin (2005). From this workshop an interest in categorizing each instrument documented in the library according to the ten DBR principles (Wang & Hannafin) resulted. Categorization has been done by three of these researchers in June 2021 (Analysis 2). The three researchers individually categorized every instrument (N=49) based on the DBR's nine principles (Wang & Hannafin). In an Excel table, each of the researchers had to inform in their opinion with "yes" or "no" whether the instrument allows them to achieve each of the principles. After an initial coding of the instruments, an affinity scale was developed. This scale includes six items created by the researchers to qualify their level of familiarity with each instrument. The purpose of this scale was to document the degree of familiarity of researchers to the instrument they categorized. With this measure, we assume that researchers consider an instrument to realize (or not) the principles of DBR based on their affinity for the instrument in question. Each instrument was therefore coded on the basis of this scale:

- 0 = I am not familiar with the instrument.
- 1 = I have already heard about the instrument / it has already been recommended to me.
- 2 = I have already used this instrument as a participant of DBR (during a workshop of a research project).
- 3 = I once have chosen to use the instrument, without modifying it, to facilitate the DBR that I am in charge of conducting.
- 4 = I have already designed/modified such an instrument depending on the context and/or based on a literature review.
- 5 = I am an expert on this instrument. I actively communicate about it and/or I create the instrument for my research context.

This encoding of the instruments was then shared and discussed among the three researchers. The main findings from this pooling are presented and discussed in Chapter 5. Thus, the research methodology is based on the articulation between a process led to the design of an

instrument library and the design of a generic model of what a DBR instrument is according to the DBR principles and the instrumentation theory. The data is produced during the entire process we have described above (see Figure 1). Through the survey (S1) and the workshops (W1 + W2) we produced and collected researchers' representations on the instruments they use and their needs for pooling these instruments. We also collected the decisions about the library's development resulting from the two workshops and several working meetings on the basis of written reports and recordings.

In this contribution, we discuss the results of our work in two sections. First, the categorization of the instrument's features gives rise to "descriptive criteria" (based on the Analysis 1). Then we discuss these criteria and present our modelization of DBR's instruments based on Rabardel's instrumental genesis (1995). In a second section, we discuss how Wang & Hannafin's principles (2005) can be used to characterize the instruments (based on the Analysis 2).

5.0 Towards a Model for DBR Instruments

In the following, we discuss the results from the categorical content analysis (Bardin, 2013) based on the survey (S) and the workshop (W1). We consider it as a bottom-up analysis because the categorization emerges from (1) the data collected with the questionnaire (S) and (2) the minutes of the workshop (W1) dedicated to designing the first version of the library. This analysis led to the selection of nine descriptive criteria for the DBR instruments. These criteria are presented in the table below (Table 1). Each criterion is described and illustrated by the example of one instrument widely used by the researchers: the Persona (Nielsen, 2013), a fictional representation of end-users dedicated to identifying their characteristics and needs. Before introducing this table, we briefly describe what is a persona activity.

The persona activity is an instrument mentioned and described by the researchers in S and W1. The personas method generally used in marketing, consists of imagining potential users of a device or service, trying to understand their needs and anticipate their behaviours (Blomquist & Arvola, 2002). This method has been adapted to the research needs in the form of a grid composed of boxes to be filled in where the persona comes to life through the attribution of characteristics, behaviours and expectations towards an educational device. It is then drawn or materialized with LEGO® pieces. This instrument is used to help the designer to momentarily decentralize from his or her posture as a designer and to involve the partners of the research projects by bringing them to share their representations of a particular target public.

Table 1: Description of the nine criteria and examples with the persona's activity

n°	Criteria	Description	Example - personas' activity
1	Description of the artifact	Description of the instrument in terms of tangible or digital artifact, such as sheets, documents, software, cards. Uses of the artifact are not documented in this criterion.	*Sheet with a grid to describe the personas (link to the instrument: Blomquist & Arvola, 2002, LEGOs (small characters with accessories)*
2	Legal notices	Information about accessibility of the instrument in terms of (1) copyright (i.e intellectual property) and (2) data privacy (personal or sensitive data)	*(1) Creative Common (CC BY NC 4.0)* *(2) No personal or sensitive data*
3	Theoretical foundation	Mention of theoretical references that present and document the instrument. They indicate to which field of research they belong.	*Nielsen, L. (2013). Personas-user focused design. London: Springer*
4	Temporality	Descriptions of the use of the instrument in terms of temporality: (1) phase of the research process, when should the instrument be used? (2) Time needed for its use?	*The sheet is used at the beginning of the project, when a needs analysis has to be carried out or the target audience has to be described. The activity takes about 1h30.*
5	Limits and difficulties	Description of weaknesses, limitations, obstacles encountered when the instrument is used	*Risk of bringing out stereotypes about the end-users.*
6	Example of use	Description of the use of the instrument in a particular context, its purpose and the barriers it helps to overcome (e.g. contributing to collaboration between professionals and researchers)	*During the project "Mission Télomère": allow to share knowledge and help to clarify representations about the end-users.*
7	Prescribers or beneficiaries	Description of the professionals who will use the instrument, in particular in terms of "prescriber" (actors who benefit from the use of the instrument by manipulating it to address a specific need) and "beneficiary" (actors who benefit from the use of the instrument by manipulating it)	*Prescriber: researcher, PhD student* *Beneficiary: the designers of the game (computer scientists, researchers, teachers, game designers, graphic designers) and the users of the game (pupils, students, teachers, …)*
8	Contact person	Mention of one or several contact persons from the lab who have used the instrument in their practice. The list of reference person does not have to be exhaustive.	*Team members or previous users who have used the instrument in the past, and who willingly share their experience.*
9	Needs	Description of the needs of the DBR that the instrument aims to answer. The need may concern the DBR process (co-problem-	*1. to bring out the cohesion between players (group dynamics) in a creative fun activity*

[redacted]	atization, co-design, co-analysis), or the DBR products (technological or scientific results).	*2. to ensure that a game is created that takes into account the learners' needs (end-users)* *3. to produce research data about teachers' perception of students*

According to Rabardel's work (1995), the nine identified criteria refer either to the artifact (criteria 1-3 in red), to the actors using it (criteria 7-8 in blue) or the way the actors use the instrument (criteria 4-6 in green). In red criteria 1-3 describe the fixed characteristics of the artifact. For example, the "description of the artifact" (criterion 1) and "theoretical references" (criterion 3) document the artifact without considering its use. On the other hand, criteria in green such as "temporality" (criterion 4) and "examples of use" (criterion 6) relate to patterns of use. Indeed, the same artifact can be subjected to different patterns of use based on the actors, their needs and constraints.

To ensure effective use of the instrument, certain criteria such as the "temporality" (criterion 4) and the "needs" (criterion 9) must be documented and updated for each new use of the instrument. Criteria "target audience" (criterion 7) and "reference persons" (criterion 8) describe the actors involved in the use of the instrument. The "needs" (criterion 9) is linked to the artifact, its uses, and the actor. It refers directly to the characteristics of the DBR, and the underlying needs they address. This criterion provides valuable information on how the instrument enables the specificities of the DBR.

The criteria are modeled based on Rabardel's instrumental genesis, which enables us to identify and characterize aspects related to the actors, usage patterns, and the needs and constraints of DBR (Figure 4).

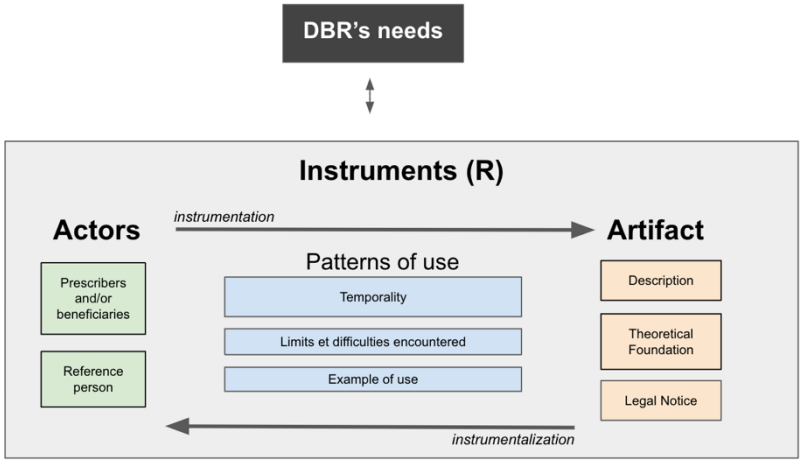

Figure 4: Model to describe instrument criteria used in DBR

The goal of instrument modeling is to accurately describe how an instrument is used in its specific context. This description requires constant documentation and updating of the instrument's use. Different

users of an instrument should have the opportunity to provide feedback criteria (4-9) based on usage patterns, the actors involved, and the DBR's needs that the instrument addresses.

Criteria 7 and 8 provide information on the effects of the instruments on the actors involved. By actors we mean researchers, teachers, or other professionals involved in the DBR. According to Rabardel (1995), we assume that the use of an instrument can affect the skills of the professional who uses it. Thus, the process of instrumentalization transforms the actor during the use of the instrument (Rabardel, 1995). It leads us to question how instruments could orientate the manner researchers define their research object. We also interrogate the skills developed by professionals using the instrument. For example, an instrument such as the "persona activity" can enhance the collaborative and creative skills of teachers who participate in the activity. It would be also valuable to document the necessary competences or theoretical knowledge required for instrument mobilization. Modelizing instruments prompt us to question how they influence the development of actors' professional skills.

DBR is conducted in different phases (Amiel & Reeves, 2008). The instruments used in research can be described on the basis of temporal characteristics. Specifically, instruments are described according to when they are used in the research process, as in the THEDRE method (Mandran, 2018) and co.LAB project (Jaccard et al., 2021). The THEDRE method proposes artifacts for each step of the research process. The co.LAB project (Jaccard et al., 2021) "aims at designing a digital platform dedicated to the design and evaluation of learning games for multidisciplinary teams working in a research context" of the DBR type (freely translated from Prior, 2021, p. 401). In this framework, resources are organized and documented in relation to the iterative phases of design and research: "design, development, test and validation, implementation, evaluation". The descriptive criteria system for the instruments presented in this paper is not based on the temporal organization of the instruments. In fact, the same instrument can be needed at different steps in the research process, and sometimes it can be suitable for use over a long period of time (several weeks or several months). Thus, criterion 4, temporality, serves to document when the instrument is used and for how long. Temporality is not the structure of the descriptive system, but a criterion within it.

In black (Table 1), criterion 9 which is titled "needs of the DBR" pertains to the specific requirements and limitations of the DBR that the instrument needs to meet. It involves clarifying the purpose of the instrument's use in relation to the characteristics (The Design-Based Research Collective, 2003) or principles of DBR implementation. In fact, Wang and Hannafin (2005) have identified nine principles that govern the implementation of a DBR based on its characteristics. These principles are designed to be practical since they are meant to be used in the implementation of a DBR. Thus, we will further examine "needs of

the DBR" criterion by discussing it from the perspective of Wang and Hannafin's principles.

6.0 Characterizing Instruments Based on Principles of DBR?

The results and subsequent discussions presented in this chapter are based on the data generated from the W2 workshop and the analysis lead in June 2021 (Figure 2). As a reminder, the objective of this workshop was to identify the DBR needs addressed by the instruments according to the DBR principles (Wang & Hannafin, 2005). The results discussed here are based on the pooled encoding outcomes that indicate whether (1) the instrument allows for each of the DBR's principles to be answered (yes/no) and (2) the researcher's degree of compatibility with the instrument being used.

The table below illustrates the number of times each principle (columns) was coded either by one researcher (row 1), by two researchers (row 2), or by all three researchers (row 3). Row 4 represents the total number of times the principle (P) was assigned. For instance, out of 49 instruments, 27 were assigned to principle P1 and only 3 of the 27 instruments were selected by all 3 researchers to fulfill this principle. However, some instruments, such as the personas, were assigned to principle P1 by all 3 coders. Additionally, it is worth noting that principles P2, P3, P8 were never coded by all 3 researchers simultaneously. Among the principles used to characterize the instruments, P1, P5 and P8 were the most commonly used (P1: 27 instruments; P5: 28 instruments; P8: 27 instruments). On the other hand, principle P3 was used less frequently (P3: 6 instruments). This suggests that according to the coders, principles P1, P5, and P8 are better represented among the existing instruments in the library, whereas P3 is not well instrumented.

Table 2: Number of times each principle is used to code an instrument by one, two or three researchers.

	P1	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**
1 Researcher	18	13	5	7	17	13	11	17	16
2 Researchers	6	4	1	6	7	3	4	10	
3 Researchers	3			1	4	5	3		
Total number of coded instruments	**27**	**17**	**6**	**14**	**28**	**21**	**18**	**27**	**16**

These results indicate variations in the categorization of instruments among the three researchers which could be interpreted in different ways. One possible interpretation is that this variability reflects a chal-

lenge in comprehending the principles in terms of their practical implementation. Mandran et al. (2022) explored the link between the THEDRE guides and DBR principles, based on the feedback of guide users. The opinions were collected during a THEDRE guide training. The study revealed that the principles were challenging to put into practice. Our findings align with this observation in the context of the instruments utilized and developed in DBR.

Another possible interpretation concerns the researcher's personal affinities and experiences with the encoded instruments. Based on their own experience with using the instruments, the researchers may perceive certain instruments as more suitable for operationalizing specific principles. For instance, during Workshop 2, Researcher 2 reported using the personas' activity on a regular basis. He considered the persona's instrument to collect data for research purposes and considered it as addressing the need to "implement data production methods in a systematic and targeted way" for principle P6. In contrast, Researcher 3 primarily used the personas instrument for conducting a needs analysis and assigned it to principle P4 "to conduct research under conditions representative of the real world".

The needs addressed by the instruments, and consequently the implementation principles selected, appear to be influenced by the researchers' usage patterns. The patterns of use of the same artifact are varied to meet different needs. Thus, the ability of an instrument to address a particular principle seems to depend on the actor's use of it. The principles are not linked with instruments solely based on the artifact itself. Rather, they must be considered in light of the usage patterns of the instruments.

The instrument affinity scale was used in this study to account for varying degrees of familiarity with the instrument. The items were used to guide discussions on the attribution of principles to the instruments, but this aspect has not been investigated. Future research could explore the correlation between the attribution of certain principles to instruments and the actors' degrees of affinity with them. This contribution highlights the importance of considering the principles of instrumental genesis and reflecting on levels of familiarity with the instrument. Adapting the affinity scale to shed light on patterns of instrument use, particularly in the instrumentation and instrumentalization processes, would be beneficial.

7.0 Conclusion

In this study, we aimed to characterize and modelized Design-Based Research (DBR) instruments based on the instrumental genesis framework (Rabardel, 1995; Trouche, 2005). We employed a bottom-up approach by conducting a categorical content analysis of survey data and workshop minutes. Our analysis led to the identification of nine descriptive criteria for DBR instruments, which encompassed the characteristics of the artifact, the actors using it, and the patterns of its usage based on the instrumental genesis framework (Rabardel, 1995; Trouche, 2005).

Through our analysis, we found that the criteria of temporality (criterion 4) and needs of the DBR (criterion 9) were crucial for documenting and updating the instruments for their effective use. Additionally, the criterion related to prescribers and beneficiaries (criterion 7) provided insights into the impact of instruments on the skills of professionals involved in DBR. We also observed that the same instrument could be subject to different usage patterns depending on the actors' needs relative to the DBR context and his degree of familiarity with the instrument. Furthermore, we explored the alignment between the identified instruments and the principles of DBR (Wang & Hannafin, 2005). Our findings indicated variations in the categorization of instruments among researchers, possibly reflecting challenges in understanding and practically implementing the principles. It appears that personal affinities and experiences with the instruments influence researchers' perceptions of their suitability for operationalizing specific principles. It became evident that the implementation of principles is closely tied to the actors' use of instruments, emphasizing the importance of considering usage patterns in relation to principles. In addition, our study revealed a link between researchers' familiarity with the instruments and the way in which the instruments are perceived as meeting the principles of DBR. Future research could delve into this aspect and explore how familiarity affects the patterns of instrument use during the instrumentation and instrumentalization processes.

In conclusion, our work contributes to the understanding and characterization of DBR instruments based on their descriptive criteria and alignment with the principles of DBR. This analysis provides valuable insights for researchers, practitioners, and instrument developers in selecting and sharing instruments that effectively address the needs of DBR. By considering the characteristics of the artifact, the actors involved, and the usage patterns, researchers can enhance their understanding of instrument design and its impact on the development of professional skills and the DBR process. As a first iteration of our work, these results enable us to pursue the development of an instrument library. Indeed, work is currently underway to design and implement a structured online instrument library based on the modeling we presented in this contribution. This study lays a foundation for further exploration and refinement of instruments in DBR.

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Journal Details

EDeR – Educational Design Research
An International Journal for Design-Based Research in Education
ISSN: 2511-0667
uhh.de/EDeR
#EDeRJournal (our hashtag on social media services)

Published by

Hamburg Center for University Teaching and Learning (HUL)
University of Hamburg
Schlüterstraße 51
20146 Hamburg
Germany
+49 40 42838-9640
+49 40 42838-9650 (fax)
EDeR.HUL@uni-hamburg.de

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In collaboration with

Hamburg University Press
Verlag der Staats- und Universitätsbibliothek Hamburg – Landesbetrieb
Von-Melle-Park 3
20146 Hamburg
Germany
+49 40 42838 7146
info.hup@sub.uni-hamburg.de
hup.sub.uni-hamburg.de