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iRPD- a Framework for Guiding Design-based Research for iPad apps

Abstract

The last five years have been marked by an explosion of tablet and smartphone applications designed for young children and marketed towards their carers and teachers. This article explores the prospects of educational researchers collaboratively researching, implementing and producing iPad apps for educational purposes. A Research, Practice and Design framework (iRPD) for guiding such collaborative efforts is provided, along with five key principles: triple collaboration, shared epistemology, awareness of affordances and interconnected social factors, and child-centered pedagogy. The novel affordances of collaboratively produced iPad apps for educational design-based research are outlined, along with several examples of how such an engagement might enrich educational research and the app landscape.

Keywords: iPads, apps, design-based research, software design

Introduction

The advent of iPads has made new tools available to educational researchers, who have begun to research the tools' educational impact and potential, but also thinking about shaping the directions of educational technology in the 21st century. Notably, the prospect of collaborative design of children's iPad applications (apps) is emerging as a new avenue for the realisation of several educational objectives. This article provides a framework that addresses the issues and benefits of a collaborative endeavour pursued by researchers who co-design and facilitate the implementation of iPad apps in educational settings. The focus is on early years education where the need for educational design-based research with iPad apps appears to be most pronounced. However, many of the affordances and uses of iPad apps described here are also applicable to older age groups and comparable tablet or smartphone apps.

iPads in early years education

Out of all recent touch-screen technologies, iPads have become ubiquitous, used by all sections of the educational community, including young children of pre-school age (Guernsey, 2012). iPads are highly customisable, intuitive touch-screen tablets which synthesise several technologies into one 'activity center' (Markopoulos & Bekker 2003,

p.142) . Several researchers have begun to document and evaluate children's everyday engagement with these tools at home (e.g. Kucirkova, Messer, Sheehy, & Flewitt, 2013) and schools (e.g. Hutchison, Beschorner, & Schmidt-Crawford, 2012). In addition, case studies illustrate iPads' potential value in contexts where traditional means of communication are limited, especially for children with autism and apraxia (e.g. Jowett, Moore, & Anderson, 2012; Flewitt Kucirkova & Messer, 2014).

So far, researchers have examined children's iPad interactions with specific, commercially produced, apps. For instance, Wohlwend (2013) looked closely at children's interactions with the Puppet Pal™ app and Rowe and colleagues (Rowe, Pacheco, Miller, & Mills, 2013) examined children's book productions with a combination of apps (Drawing Pad™, Book Creator™ and iBooks ™). Only a few educational researchers have engaged in iPad app co-development or co-design and have been actively engaged in facilitating app implementation in classrooms.

Considering the fact that educational apps contribute more than 16 % of the total app market (Avtar, 2014), iPad apps represent a considerable challenge for educators and educational researchers. Although with educational apps, researchers have a unique opportunity to' influence both policy and practice in a touchscreen world' (Fletcher-Watson, 2013, p.58) it has been pointed out that educational researchers have 'failed to keep pace with the exponential growth in this technology' (Goodwin & Highfield, 2012, unpaginated). Thus far, the primary focus of educational app research has been the evaluation of commercially-

produced iPad apps (eg Falloon & Khoo, 2014; Hutchison, Beschorner & Schmidt-Crawford, 2012) rather than including research initiated by the teachers or that undertaken with the aim of co-producing apps as novel educational resources together with app designers. There is scope to involve all stakeholders, but currently, there is no framework which would provide a way of thinking about this process in real and meaningful terms and which would provide concrete parameters for guiding researchers in a more participatory engagement with iPad apps. This creates what Selwyn (2010) described as a gap between the 'rhetoric of educational technology scholarship' and the reality of its implementation (p.72).

Design-based research (Barab & Squire, 2004) provides a broad context within which to map collaborative endeavours between researchers and designers and researchers and teachers. Design-based research is a key approach to inform app design, as its outcomes can be both theoretical and practical and because of its dual perspective on software design and collaborative research (Barab & Squire, 2004; Reinman, 2011). This article focuses on a specific kind of design-based research, namely that which incorporates collaboratively produced iPad apps with practitioners (or teachers and professionals) together with app designers: Research, Practice and Design for iPad apps (iRPD). I begin by outlining the benefits of educational researchers engaging with iPad apps, followed by presenting the framework and its five principles which govern the dynamics of iPad app design-based research.

Benefits of iRPD engagement for educational researchers

The Research, Practice and Design for iPad apps framework provides several benefits for researchers, practitioners and app designers, as well as the end user ecosystem. While there are mutual benefits for all three stakeholders arising from this collaborative endeavour, it is beyond the scope of this article to elaborate the distinct benefits for all three. Building on extant frameworks in the area and their benefits for practitioners and research participants, this framework focuses on benefits for educational researchers. More specifically, it complements current frameworks concerned with the evaluation criteria of subject-specific apps, see for example, Goodwin & Highfield (2014) for mathematical apps; e.g., Author (2014a) for literacy apps, and Cherner, Dix & Less (2014) for educational apps, as well as checklist-like heuristics outlining steps necessary for designing apps for preschoolers (Shoukry, Sturm.C & Galal-Edeen, 2015).

Several studies describe how digital technologies blur the traditional roles of researchers and research participants, positioning participants alongside researchers as co-researchers (e.g., Gallagher, Wessels, & Ntelioglou, 2013). With apps in particular, researchers have documented how these blur the lines between researchers and participants (Kerawalla, 2014) and have suggested their affordances have the potential to disrupt traditional hierarchical relationships between adults and children (Underwood & Farrington-Flint, 2014). This concept is elaborated later in this paper. In this section, it is important to recognise why research with

apps is different from other technologies and what their unique affordances for educational researchers are.

First, involvement in app co-production provides educational researchers with a novel dissemination opportunity afforded by the ongoing technological revolution in education (Csete, Wong, & Vogel, 2004; D'Souza, 2013). Unlike with other software programs, apps enable researchers to reach the public in a quick, continuous and iterative manner. For instance, if a research team co-develops an app and needs to update their research findings (e.g., by extending their previous research to a new user group), they can release these in the form of an app update and easily include more options in the app settings (e.g., theme selection for the app depending on the age group of users). Also, via local notifications or Apple's support downloads sites, updates are easier and can be an accessible, freely available and easily executable means of reaching diverse sections of the public in a timely and efficient way.

Also, iPad apps could contribute to new models of open access/open source publishing (Lane & Darby, 2012) and richer assessment of scholarly impact. For example, the number of downloads and length of use of a collaboratively produced app could be taken as an indicator of the practical impact of a piece of research. Such metrics might establish broad estimates of the number of people reached by a specific research initiative and could become a new metric to be included under the banner of altmetrics (see http://altmetrics.org/manifesto/). Overall, with co-

produced apps new public audiences can be reached to increase as well as evaluate the impact of empirical work (cf Tseng, 2012).

Second, iRPD engagement can directly contribute to the quality of apps offered to young children by introducing empirically determined effective apps. It has been pointed out that the majority of apps advertised as educational have been designed 'without explicitly considering how children learn, or how the electronic medium can be harnessed to use its unique affordances to support learning' (Zosh, Hirsh-Pasek, Golinkoff, Gray, Robb, & Kaufman, 2013, p.4). Chau (2014) examined the extent to which children's apps promote the optimal development of children and found that only 58% of the children's apps examined were designed in a developmentally and educationally appropriate way. If educational researchers closely collaborate with the app producers, this can become a source of inspiration for improved app designs (Author, 2012, 2013) and can be a novel way of implementing research insights into practice. Moreover, it could address the reported disconnect between app design and app research and the fact that the majority of children's applications currently advertised as "educational" have little educational value and research base (Ólafsson, Livingstone, & Haddon, 2013; Simpson, Walsh, & Rowsell, 2013; see also Gunter, Kenny, & Vick, 2006; 2008). In 2012, Shuler and colleagues reviewed and analysed apps featuring in the Education Category of Apple's App Store and concluded that 'developers and researchers should work together toward the design of effective, high-quality products' (p.4).   This echoes

the call of policy makers who have suggested that researchers should be continuously engaged with software designers and 'ensure the provision of greater transparency regarding how data are collected, collated, used and shared via children's apps' (Holloway, Green, & Livingstone, 2013). Recently, Falloon (2013) extended this call to teachers: after closely studying children's interactions with iPads in an early years classroom, Falloon (2013) concluded that researchers and children's teachers engaged with iPads need to join forces to provide children with educational benefits.

Third, a key advantage of using iPad apps for practice, research and design is the possibility to facilitate communication and develop relationship with the users. With additional tools like for example Apptentive™, in-app surveys and conversations inside the app can be enabled. With multiple device management systems (eg Airwatch ™), researchers or teachers can easily enrol devices remotely and push app updates over the air, thus providing each pupil with the same experience at the same time. Such technological solutions could become an alternative means of implementing accumulated knowledge of the research discipline (cf. Liska & Cronkhite, 1994). For instance, researchers could evaluate an educational technique (e.g., reading a short story) for a specific period of time, let students customise the reading experience (e.g., adjusting the reading speed, see Spritz™), invite them to provide feedback from within the app, make students' comments accessible to pre-selected groups and monitor students' engagement in

the entire activity with an embedded recording software. While such users' evaluation is one of the main interests in the business field, it represents a unique opportunity for educational research and may decrease the criticism that educational research produces little applied knowledge (Ball, 2012) and lags behind the technological advances that invade 21st century society (Green & Beavis, 1998).

Inevitably, design-based research with iPad apps introduces not only benefits but also several challenges for educational researchers. Many of these challenges are not unique to iPad apps, and include logistical challenges associated with organizing novel resources, activities and overall system components contributing to the resource use, as well as 'a paradigm shift caused by the new participatory, iterative and collaborative approach' (p.17, Chmiel, 2011). Resolving these challenges requires developing an approach that incorporates principles of effective design-based research (The Design Based Research Collective, 2003; Wang & Hannafin, 2005) and that capitalises on the novel affordances of iPad apps. Both approaches are integrated in the iRPD framework, outlined next.

The iRPD framework

According to Nigg and Jordan (2005, p.292) 'framework is a set of assumptions, concepts, values and practices that constitutes a way of viewing reality'. The iRPD framework is not a mechanism for evaluating researchers' approach to design-based research with apps nor is it a code

of practice. There are several frameworks for research-design engagement (see Siau & Rossi, 2007 for an overview) and there is also abundant guidance for designers of educational multimedia resources, with, for example, Churchill's (2012) conceptual model for designing learning objects. What is missing is a framework which would bring together teachers, researchers and designers into one space specifically focused on iPad apps. The aim of the iRPD framework is to address this gap and to serve as a guide, or scaffold, for educational researchers entering the field of design-based research with apps.

Origin of the framework

The author has been involved in the development of an iPad app to support children's story sharing (reference withheld, referred to as OS hereafter) and is currently working on a suite of research-based apps related to early literacy education. Collaboration with app designers and practitioners has been attained using the OS app and co-design activities were utilized to develop the content of the software. The result of these efforts has been a series of research studies (Author, 2011, 2012, 2013, 2014a, 2014b) and the actual OS app, which has featured as the second best educational app in 2011. Based on an extensive literature review and reflecting on personal experience, a framework was developed to guide future efforts in the educational design-research with iPad apps. The iRPD framework integrates five principles which can be used to understand nuances in educational design-based research with these

tools, and inform researchers' decisions whether to engage in such an endeavour.

In the spirit of educational design research to promote 'deep understanding of innovations and the factors that affect improvement in local contexts' (Anderson, 2005, unpaginated), the framework does not purport to offer universal solutions or offer guidance for measuring the effectiveness of such engagement. Rather, the framework is a special case nested within the larger framework of educational design-based research (Siau & Rossi, 2007; McKenney & Reeves, 2012) and complements current efforts in the design-based research area which focus on process-oriented (e.g. Reeves, 2000; Bannan-Ritland and Baek, 2008) or concept-oriented models (e.g. McKenney, van den Akker and Nieveen, 2006; Reinking and Bradley , 2008) and wider theoretical frameworks guiding researchers co-designing learning objects (e.g. Churchill, 2012).

With a specific focus on educational apps, the framework could be also regarded as a partial response to the calls to encourage more educational researchers in iPad app research (e.g., Shuler, 2012; Fletcher-Watson, 2013; Chau, 2014). The five principles, graphical representation of the framework and description of the researcher's role in iRPD serve as a heuristic for understanding the interaction between conditions and resources shaping app production in educational research and the multiple factors influencing it.

Principle 1: Triple collaboration

Traditional design-based research is 'based on collaboration among researchers and practitioners' (p.6, Wang & Hannafin, 2005). A distinct feature of the iRPD framework is that in addition to practitioner-researcher and researcher-designer collaboration, it fuses all three stakeholders into one collaborative design research space of educational apps. A practitioner- designer collaboration can help generate scalable improvements for specific software (Hoadley & Kilner, 2005) and a researcher acting as co-practitioner is likely to better understand the practical validity of his or her approach (Hosking & Pluut, 2010).

A three-way collaboration among all three stakeholders represents a unique opportunity to directly address some of the practical challenges of apps' implementation in educational settings. For example, Baker (2013) describes the difficulties of implementing apps for oral composition in classrooms, with apps calibrated for adults' but not children's voices and thus undermining their independent use by children. Similarly, Rowe (2013) documented how apps designed for young children's book composing did not always perform as intended and their use was accompanied by children's frustrated calls for adults' help when some of their book contents were lost. Clearly, there is no single solution for these challenges but it is conceivable that some of the practical challenges of iPads' deployment in educational environment can be addressed through design improvements by researchers who are documenting these challenges and directly reporting to the app designers.

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Using the OS app in one primary school in English Midlands, we worked with three teachers, each of them from a different year group (Foundation, Year2 and Year3). When we started the project, we encouraged the teachers to use the app in their respective classrooms as they deemed best. All three teachers had different ideas for using the app: The Year3 teacher used it to enrich his History lessons, the Year2 teacher to improve his children's diary writing skills and the Foundation teacher used the app to personalise children's stories shared in the classroom. Our informal observations of teachers' varied deployment of the app provided a number of insights for further development of the software. For example, we implemented features in the second version of the OS app, which had been envisaged in conversations with teachers about children's preferences for book-making. The teachers reported children's preference for small-format books, and as a direct consequence, in the second OS app we made it possible to print small A6 books in addition to standard A4 sizes. In addition, the Foundation teacher voiced her preference for being able to automatically turn off the spell-checker and we enabled this feature with the OS2 app upgrade. These seemingly small changes to the app design affected children's writing and engagement in book-making. The interests of the Year3 teacher and his colleagues inspired the possibility for using the app for short research reports a design feature we aim to implement in the fourth edition of the OS app. These insights wouldn't be possible if we didn't act as co-designers or if we didn't work closely and directly with the app designers.

Thus, regular informal discussions and structured workshops with teachers and designers facilitated by us, researchers, can feed into an iterative development process of an app. Researchers' role in such collaborative teams is to ensure that the team is focused on the task, that there is an efficient progress and continuous improvement of the shared

practice and that the trio lives by the values and practices of their shared epistemology.

Principle 2: Shared epistemology

As a second principle, the iRPD framework postulates that for effective iPad practice and design, it is important to align the collaborative efforts with a clear epistemology shared by all three stakeholders. Epistemology is what an individual researcher understands as falling within the domain of 'knowledge' (Nonaka, Von Krogh, & Voelpel, 2006, p. 1180) and what s/he believes is the nature and justification of human knowledge (Hofer & Pintrich, 1997). Distinct epistemologies imply a different understanding of what defines successful learning environments and tools supporting these (Plowman, 1995). For example, a researcher who holds a dialogical epistemological stance follows a different research methodology than a researcher who views learning as a dialectic unity. While in empirical approaches, the quality of a piece of research is judged based on the alignment between epistemology and methodology, in practice and design this alignment is rarely attained or even sought-after (Yanow, 1990).

Educational researcher who engages in design research with iPad apps needs to ensure that s/he adopts an epistemology which would reflect the pedagogical knowledge of the practitioners as well as the objectives of the app designers. Both stakeholders, however, might conceptualise epistemology differently. For practitioners, epistemology refers to their view about what a particular subject is. For example in the

case of mathematics, epistemology is 'what it should be, what it entails, how it is to be carried out. (…) A teacher's own (implicit or explicit) mathematical epistemology is an essential tool for the assessment of children's mathematical ability' (van Oers, 2002, p.22). For designers, epistemology relates to the strategic plan and objective of the products they design. When designing iPad apps, clear epistemology is important for achieving consistency and aesthetic integrity and for providing 'an internally consistent experience' and 'send a coherent message' (https://developer.apple.com/library/ios/documentation/userexperience/conceptual/mobilehig/Principles.html). In collaborative iRPD efforts, there is no need to have one singular epistemology, indeed as Bell (2004) writes, there is no 'singular syntax and epistemological core—which will map onto the complexity of design-based educational endeavors' (p.249, Bell, 2004). What is important, however, is that in each project, all three stakeholders agree on one shared epistemology which guides their work. The role of the researcher is to ensure that the teachers/practitioners and app designers involved in the project share a set of values and an understanding of the scope of the project.

Figure1 provides a graphical summary of the first two principles, with a shared area of researchers, designers and practitioners to demonstrate their relative importance in the app development process. The circle represents the shared epistemology uniting all three stakeholders together and connecting them to the jointly shaped educational app, represented with a grey square.

Figure1 to be inserted about here

Principle 3: Interconnected Social Factors

A distinct feature of the iRPD framework is its network of interconnected socio-cultural relationships pervading the work of all three stakeholders. The socio-cultural factors influence all stakeholders and their collaboration in developing the apps in an iterative (circular) fashion. This aspect of the framework is similar to that of Social Infrastructure Framework (Bielaczyc, 2006) which advances the methodology of design research by recognizing the importance of inter-connected variables in a given system. Similarly to the Social Infrastructure Framework, the iRPD framework identifies the interaction among stakeholders' beliefs, social and economic factors, moral values, cultural norms and political factors. Unlike the Social Infrastructure Framework, the iRPD framework suggests a direction of flow for the individual variables comprising the system. Notably, it specifies the relative value of any of these factors and positions them on a circular line (see Figure2). This illustrates that the social, cultural, moral, financial and political values support and constrain the framework's internal system of operation and pervade the collaborative work of all three stakeholders. The researcher-designer-practitioner trio must thus work together to resolve issues arising from the influence of these factors on an app's production. Progression through the cycle occurs in an iterative way, with researchers at times taking on roles of practitioners or participants and practitioners acting as co-researchers. This facilitates the integration of usability and usefulness of apps into the

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practice of the individual stakeholders (Author, 2014c). As such, the final product of an iPad app is a result of a constantly evolving process characterised by a dynamic interaction among internal and external variables shaping educational research. This is closely related to Lyon's (1994) notion of technology conceptualised as an activity rather than a tool, indicating the importance of social factors involved in any software production. Interconnected social factors are closely associated with the affordances of resources that support a given system and it is crucial that all three stakeholders are fully aware of these.

Principle 4: Awareness of app affordances

The iRPD framework encompasses the notion of affordances, borrowed from the ecological theory (Gibson, 1977). Gibson and colleagues conceptualise affordances as offers of the environment, which need to be discovered and realized by the agent through action (Gibson and Pick, 2000). The notion of action is crucial here, as Gibson emphasised that it is only through action that new understandings become available. This maps onto the iterative nature of educational design research, which typically evolves through multiple cycles of design/ development, editing/ revision and testing/ evaluation (McKenney & Reeves, 2012).

Gibson's (1977) emphasis on realisation of affordances through action is also relevant for a meaningful engagement of all three stakeholders in the project. Thus far, design-based research has been

predominantly concerned with school- or child-level interventions (Honig, 2013), with little attention paid to the actual design of tools facilitating these interventions. In its simplest terms, the iRPD framework argues that close collaboration implies shared resource (ie the app), which can act as an internal tool, supporting all three stakeholders in their individual activities. Fletcher-Watson (2013) points out that the' most notable implication of evidence-based app design is the opportunity it offers for the creation of credible and useful information for parents' (p. 60). iRPD framework expands this to researchers, designers and educators who could use the app to store and share useful information. For example, researchers can use JavaScript/HTML-based methods to collect experimental data with toddlers using iPad apps (Frank, 2013) and teachers can use apps to store information about individual children, including photographic evidence of children's achievements or parents' contact details (see Mengoni & Oates, 2014).

So that all stakeholders become fully aware of the app affordances, the researcher needs to set out time and space in which the practitioners, app designers and research team explore the tool's affordances together and determine its potential for their own and others' work (Author, 2014d). This recommendation builds on previous research on effective technology deployment, for example Pegrum, Howitt and Striepe (2013) found that iPads can contribute to pre-service teachers' learning, but they need to have the motivation, time and enough opportunities to take advantage of the devices' affordances. Once familiar with the tool,

several intervention components can be embedded in the app, including information on context of use, reminders, feedback or peer support, intensity, duration, personalisation and theoretical basis of the research. This may help with implementation of usable knowledge at a larger scale, which is an often reported challenge of design-based research (Design-Based Research Collective, 2003).

Principle 5: Child-centred pedagogy

The fifth principle relates to the central *and active* role of children in the practice, research and design of iPad apps. Although all stakeholders are connected to children through their individual agendas, in collaborative iRPD projects, they have a shared commitment to the children's active participation in the cycle of educational research, practice and design of apps.

There are various understandings and possibilities of positioning children as co-researchers (Kellett , 2005) and with the advent of new technologies, these possibilities have become more varied and immediate (Druin, 2005; Marsh & Richards, 2013). In our work, we saw how children's participation in the research process provided novel insights into the educational processes under investigation (Author, forthcoming). Child-centred pedagogy for teachers means that children could act as active facilitators of iPads' use and implementation in the classroom. Several schools encourage children to act as digital leaders (see eg https://nickynewbury.wordpress.com/tag/digital-leaders/) and this could

be extended to iPad apps, with children advising on apps' selection, updates and accessories. For designers, positioning children as co-designers means extending their involvement in the evaluation of finished products or services (Alderson, 2008) to the product design (Bers, 2012). The latter, app design and app coding, is relevant for nurturing children's coding skills and computational thinking – skills which are promoted in the US and UK primary schools as part of national curricula.

Although presented in a chronological order, there is no intended hierarchy in the five principles presented here. They are presented as individual facets in order to afford detail of the key issues with regard to each. However, in real life, there is a strong interactivity among them, as represented with a double arrow in Figure2.   *Insert Figure2 about here*

Conclusion

Reports indicate that the use of educational apps is permeating all levels of society, regardless of their socio-economic status or literacy levels (Levine, 2012). Several calls have been made for greater researcher involvement in iPad apps design and practice (Ebner, Kolbitsch, Stickel, 2010; Huber & Ebner, 2013). Underlying these calls is a shared concern and common commitment of researchers and educators to produce educationally sound resources for young children. Educational design research with iPad apps could provide some unique opportunities for the dissemination and utilisation of educational research in the 21st century.

This article outlines researcher's role and some key principles which could be used as a referential anchor for guiding current and future efforts in this area. The iRPD framework does not provide a solution for systematically addressing issues of the current app design industry or of the design-based research field more generally (Barab & Squire, 2004). Rather, the framework specifically addresses educational design-based research with iPad apps and postulates that researchers, designers and educators need to engage in a three-way collaboration and actively involve children in this cycle. To make the three-way collaboration effective, researchers, designers and practitioners need to share a clear epistemology, recognise the dynamic, socially-mediated influences on an app's production, and be actively engaged in understanding the app's affordances for their collaborative work. This will allow them to contribute to wider theoretical understanding of the merits of design-based research for education (Bell, 2004) and effectively add to the empirical base of children's educational iPad apps.

In conclusion, educational design research with iPad apps is one of the 'myriad of approaches' (McKenney & Reeves, 2012, p.3), characterising design-based research which bears a strong potential to 'evoke new dimensions in old realms' (Howard, 1998, p.13). The iRPD framework aims to provide researchers, designers and practitioners with some thinking tools if they choose to progressively refine their practice with children's iPad apps and to enrich traditional design-based research with novel affordances of 21st century technologies.

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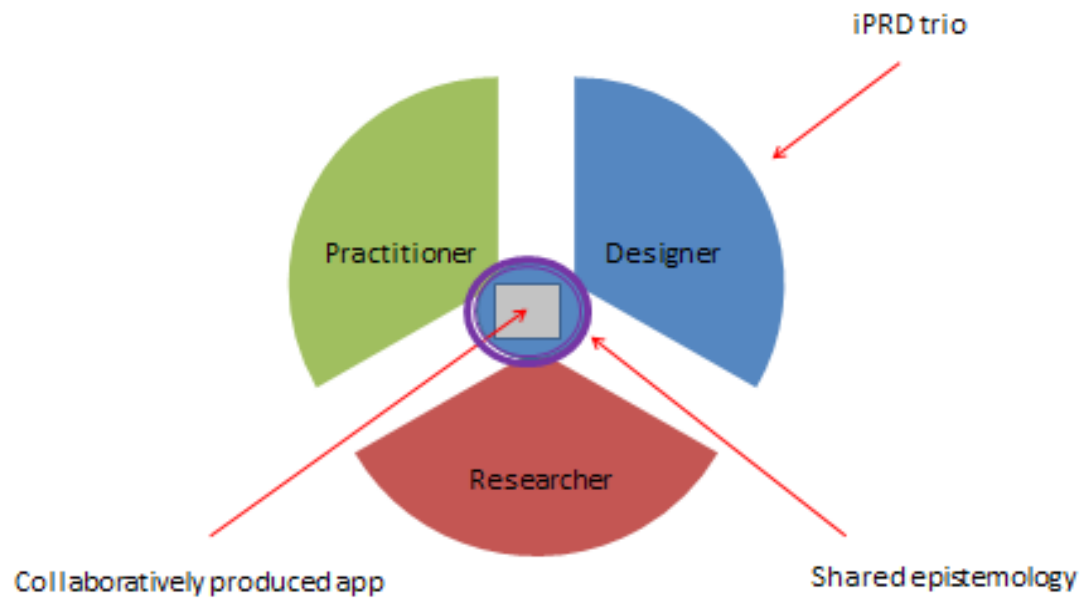
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Figures

Figure 1. iRPD framework and its first two principles

Figure 2. iRPD framework with its five key principles