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## Supporting Knowledge Integration with Low-Code Development Platforms

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# SUPPORTING KNOWLEDGE INTEGRATION WITH LOW-CODE DEVELOPMENT PLATFORMS

*Research paper*

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## Abstract

*By doing away with the necessity of writing code, low-code development platforms (LCDPs) offer to open up software development to non-IT employees. Consequently, they hold promise for harnessing specialized knowledge that is distributed across an organization for innovation. While the adoption of LCDPs is accelerating in organizations, academic scholars are yet to focus on their particular characteristics and their potential to support knowledge integration between the business and IT. We examine the research question: how can LCDPs support the integration of specialized business and IT knowledge during innovative application development? Using the knowledge-based view as a conceptual grounding, we conduct an exploratory study of selected LCDPs. We find that LCDPs can support business and IT units to integrate rather than transfer their specialized knowledge. We show how one particular digital technology – LCDPs – can play an operant role in innovation and help bridge the business-IT gap.*

*Keywords: Knowledge integration, Innovation, Application development, Low-code development platform.*

## 1 Introduction

Digital technologies play an increasingly active role in innovation (Nambisan, Wright and Feldman, 2019). Most prominently, today's organizations leverage new digital technologies not only to develop marketable products and services, but also to transform existing work routines and processes (Fitzgerald *et al.*, 2014). From research in the field of innovation management, it is becoming evident that capturing value with digital technologies requires the interaction of a set of actors with diverse knowledge specializations (Nambisan *et al.*, 2017). In particular, the development of new value-adding software requires the application and synthesis of both in-depth business and IT knowledge (Tiwana, 2004; Peppard, 2018), suggesting that successful software innovation is intimately linked with the efficient integration of knowledge held by various innovation contributors.

Knowledge integration – applying and synthesizing specialized knowledge residing in disparate parts of an organization – is a long-standing challenge. This challenge is particularly evident in the context of software development and has traditionally been aggravated by the gap between business and IT units in terms of their differing languages, cultures and ways of working (Ward and Peppard, 1996; Peppard, 2018). Although this gap has been the subject of extensive research in the past decades (Peppard and Ward, 1999) and there is growing momentum for collaborative ways of working – such as cross-unit teams and governance forums (Fitzgerald *et al.*, 2014; Peppard, 2018) – the gap still persists in many large organizations, hindering their ability to successfully innovate at the pace required in the digital world (Peppard, 2018; Leonhardt, Hanelt and Kranz, 2020).

An increasingly adopted technology, low-code development platforms (LCDPs) holds promise for bridging this gap and facilitating knowledge integration between business and IT units. Leveraged primarily to drive innovation (Rymer and Seguin, 2019a), LCDPs are characterized by a visual interface that is used to combine pre-coded development components to build software applications. By doing away with the necessity of writing code, LCDPs reduce the amount of extensive technical knowledge needed to develop applications. They thus hold promise for opening up application development also to non-IT employees who hold in-depth business knowledge and consequently, harnessing specialized knowledge from across an organization. Although some case studies have documented how LCDPs can support application development by business units (e.g. Totterdale, 2018; Zolotas, Chatzidimitriou and Symeonidis, 2018), little is known about how these platforms can be leveraged to pursue innovation. More broadly, research on digital technologies is yet to gain momentum (Lokuge and Sedera, 2018), despite suggestions that they can play an increasingly operant resource in innovation (Nambisan, Wright and Feldman, 2019). Our research starts to fill this gap and answers calls for research focusing on the detailed characteristics of digital technologies (Nambisan, Wright and Feldman, 2019) and in particular, the role knowledge plays in digitized organizing contexts (Yoo *et al.*, 2012). We pose the research question: how can LCDPs support the integration of specialized business and IT knowledge during innovative application development?

We examine our research question by performing an exploratory study of 12 selected LCDPs. As our conceptual grounding, we draw on elements from well-established literature on knowledge integration (Grant, 1996; Alavi and Leidner, 2001). We uncover five characteristics that enable LCDPs to support specific knowledge integration mechanisms which we formulate into a set of propositions that capture LCDPs as platforms for knowledge integration. Our propositions shed light on how one particular digital technology – LCDPs – can be used to harness distributed organizational knowledge to drive innovation (Fitzgerald *et al.*, 2014). Our research aligns insights from established knowledge-based literature (Grant, 1996; Alavi and Leidner, 2001) with more recent research on digital technologies' growing role at the core of innovation (Nambisan, Wright and Feldman, 2019).

This paper is structured as follows. First, we examine the conceptual grounding for our study and provide background to LCDPs. We then describe our exploratory research methodology and present our findings. Next, we provide our propositions and further discuss our findings, together with acknowledging the main limitations of our study and highlighting avenues for future research. Finally, we provide a brief conclusion.

## 2 Background

### 2.1 Knowledge integration in application development

Building on the resource-based view of the firm, the knowledge-based view posits that knowledge is the most strategically important resource for a firm and a driver for competitive advantage and superior performance (Grant, 1996). A firm is seen as a structure whose main aim is to bring together individuals possessing specialist knowledge and provide them with a set-up where they can apply and integrate that knowledge in a productive manner. The primary task for management is to define this structure in a way that such knowledge integration and application can be optimized (Grant, 1996). While Grant (1996) provides no one definition of knowledge integration, in this paper we use the term to refer to the synthesis and application of specialized knowledge. We therefore view knowledge integration as a vital component and precursor not only to an organization's competitive advantage but also to its innovation capability (Subramaniam and Youndt, 2005). Knowledge integration is a multilevel concept as knowledge is held and acted upon primarily at an individual level, integrated in collaborative interactions with others and across units, finally rolling up into an organizational capability.

Central to the notion of knowledge integration is its distinction from knowledge transfer. Transferring knowledge typically refers to passing knowledge from one site or individual to another, for instance in the form of verbal or written communication (Alavi and Leidner, 2001). Previous research has highlighted the limits of knowledge transfer, such as the contextuality and “stickiness” of knowledge where

it is created and held (von Hippel, 1994) and the potentially limited absorptive capacity of the recipient (Cohen and Levinthal, 1990). In essence, knowledge transfer is seen as more time-consuming and costly than knowledge integration (Alavi and Tiwana, 2002). This is particularly the case for tacit knowledge which is embedded in the context it exists in and which is often difficult to communicate to outsiders (Grant, 1996). In contrast to transferring knowledge from one site to another, knowledge integration refers to the synthesis of specialized knowledge while working on a task. Knowledge integration aims to establish an optimized mode of interaction so that individuals can apply their specialized knowledge and embody it in the form of a product (Grant, 1996). Such knowledge integration is commonly seen as the source of creativity and the strength of cross-functional teams that bring together specialists from various domains (Cooke *et al.*, 2000; Tiwana and McLean, 2005). Rather than each specialist teaching the other team members all they know about their particular domain (knowledge transfer), the team members establish a mode so that they can effectively interact to accomplish the objective they have been set (knowledge integration). The task for management is to enable knowledge integration by coordinating and providing the structural backdrop for this interaction (Grant, 1996).

The literature identifies three principal mechanisms for knowledge integration: rules and directives, organizational routines, and group problem solving and decision-making (Grant, 1996; Alavi and Leidner, 2001; Alavi and Tiwana, 2002). *Rules and directives* include coordination elements such as plans, instructions, policies and standards which direct individuals' behaviour and minimize required communication while performing a task (Grant, 1996). Such rules and directives are particularly useful in allowing specialists to make their knowledge explicit and communicating it to a wider audience of non-specialists (Alavi and Leidner, 2001). *Organizational routines* involve developing processes, interaction protocols and agreements for task coordination (Alavi and Leidner, 2001). They allow individuals with specialized knowledge to contribute to the task at hand somewhat independently and can support complex interactions between specialists by reducing the need for direct verbal communication (Grant, 1996). In particular, routines "allow individuals to apply and integrate their specialist knowledge without the need to articulate and communicate what they know to others" (Alavi and Leidner, 2001, p. 122). Finally, *group problem solving and decision-making* consists of the formation of self-contained task teams and meetings with rich interaction. As a rich and communication-intensive mechanism, it is particularly suited for tasks which are highly complex and uncertain (Grant, 1996; Alavi and Leidner, 2001).

Adopting the knowledge-based view, application development can be framed as an activity that is underpinned by knowledge integration. Knowledge integration occurs in the interactions of the members participating in the process of developing an application (Bhandar, Pan and Tan, 2007). An application is the embodiment of organizational knowledge that has been synthesized from distributed units of the organization and that has been applied in the design and production of an application (Tiwana, 2004; Peppard, 2018). This framing regards specialized knowledge as a key input that can turn an application into a true value-adding component within an organization. Knowledge integration in IT development has typically been achieved with the means of IT governance and elements such as cross-unit and cross-functional forums and steering groups which bring together participants from distinct parts of an organization for interaction (Peppard, 2018). While distributed knowledge can also to some extent be captured and made explicit in the form of documentation or knowledge management systems, it often remains unarticulated in more tacit forms of individual intuition and know-how (Alavi and Tiwana, 2002). Such tacit and highly contextual knowledge has however been suggested to be particularly valuable for innovation (Von Krogh, Ichijo and Nonaka, 2000) also in the digital age (Kohli and Melville, 2019) which is why understanding how to harness it is of the essence for today's organizations.

Our aim in this paper is to examine how a new digital technology, LCDPs, can facilitate this task of integrating specialist knowledge distributed within an organization. To further narrow the scope of our study, we examine LCDPs' potential to support the integration of specialized business and IT knowledge during innovative application development through the three mechanisms described above. With specialized business knowledge we refer to business-oriented knowledge relating to aspects such as the organization's processes, products, services and customers. In contrast, specialized IT knowledge refers to technical-oriented knowledge relating to aspects such as development and architectural practices and

programming skills. Both types of knowledge are typically held by individuals based in their respective organizational units. Finally, both are underpinned by the organization's operational and strategic contexts that they are set in (Grant, 1996), for instance in terms of the organization's ways of working, legacy system landscape and overall strategic objectives.

## 2.2 Low-code development platforms

The term low-code development platform (LCDP) can be traced back to the analyst firm Forrester who coined the term in 2014 and has conducted extensive research on the topic since. They define LCDPs as “platforms that enable rapid application delivery with a minimum of hand-coding, and quick setup and deployment” (Richardson and Rymer, 2014, p. 2). While LCDPs gained initial attention as technology platforms that could be used primarily to develop external customer-facing applications, they have recently gained momentum also for building extensive applications for internal operational use (Richardson and Rymer, 2014; Rymer and Seguin, 2019b). Well-established technology vendors such as Microsoft, Oracle and Salesforce have also recently taken steps to enter into the LCDP space, legitimizing the LCDP market and its potential for the future (Rymer, 2017b).

Instead of writing code, LCDP developers – commonly referred to as citizen developers – work on a visual canvas to join pre-programmed components into software applications. The consequences of this are threefold. First, this makes LCDPs particularly well-suited for working on new, innovative ideas whose requirements only become clearer as different functionalities and features can be experimented with rather freely (Richardson and Rymer, 2014; Rymer and Seguin, 2019a). Second, applications can be built faster, with Forrester estimating application delivery to be up to 10 times faster on LCDPs in comparison to traditional processes (Rymer, 2018). Third, as little actual coding is required, LCDP users need to have little technical knowledge and can therefore come from distinct parts of the organization and have distinct professional backgrounds (Rymer and Seguin, 2019b). LCDPs can be seen as a digital technology platform with the potential to involve an evolving set of actors with distinct knowledge specializations in innovative application development.

Previous research has associated digital technology platforms with organizations' innovation capability when used in conjunction with the rest of the IT portfolio (Sedera *et al.*, 2016). The digital entrepreneurship literature (Nambisan, Wright and Feldman, 2019) also shows that the use of technology platforms can support the creation of innovations by non-IT employees. In a historical sense, LCDP development draws close parallels with the long-standing notion of aiming to decomplexify the development process (Gaggioli, 2017). As an example, rapid application development (RAD) methods are also characterized by iterative development cycles, together with the re-use of development components and high user engagement (Ismail, 2017; Vincent, 2019). Similarly, citizen development can be argued to be an existent concept, albeit thus far usually done covertly in the form of shadow IT. Accordingly, an earlier study on shadow IT (Kopper, 2017) finds that practitioners have already identified LCDPs as a viable technology option where the underlying platform is controlled and managed by IT, but some application development activities are undertaken by citizen developers. Notably, the practitioners interviewed for the study also recognized the advantage citizen developers have in terms of possessing in-depth knowledge of their own business areas and highlighted the benefits of allowing them (instead of IT) to undertake some development activities.

Researchers, analysts and practitioners have therefore recognized digital technologies' and in particular LCDPs' potential for harnessing knowledge from disparate locations of an organization to drive innovation. Coupled with a paucity of academic studies focusing on LCDPs, these observations motivated us to conduct an empirical study into LCDPs' potential for knowledge integration. Relying on knowledge integration – rather than knowledge transfer – would be especially relevant during the development of innovative applications whose requirements are often fuzzy. While LCDPs are at the heart of our study, LCDP adoption encompasses not only the implementation of a technology but also a shift in development methods, approaches and practices either intentionally or unintentionally (Richardson and Rymer, 2014). Consequently, we take a sociotechnical view towards LCDPs, considering also the organizational and process-related aspects of LCDPs (De Reuver, Sørensen and Basole, 2018). Our

study thus answers the call for research focusing on how new digital technologies can “serve as an active ingredient in fuelling innovative initiatives” (Nambisan, Wright and Feldman, 2019, p. 2). We describe our research approach next.

### 3 Methodology

#### 3.1 Data collection

Given the scarcity of academic studies into LCDPs, our overall aim was to gain an extensive initial picture of LCDPs and how they could support knowledge integration between the business and IT units of an organization. As yet, few organizations are using LCDPs extensively for citizen development (Vincent *et al.*, 2019) impeding access to primary data regarding LCDP use. Thus, to gather rich and well-rounded data to analyse our research question, we chose to collect three types of data: (1) expert interviews with an LCDP vendor, publicly available (2a) LCDP product review data and (2b) archival data on LCDPs from analysts and selected LCDP vendors. This extensive data set allowed us to understand not only the LCDPs’ functionalities, but also the team and organizational contexts in which the platforms were typically used and how those possibly differed from traditional development settings. For the purpose of opening up IS research into the emergent phenomenon of LCDPs, we consider our data to provide broad and rich insights of LCDP characteristics and use.

In the first step of our data collection (1), we conducted 10 expert interviews with executives and employees of an LCDP vendor (see Table 1). These interviews were exploratory and performed as part of a larger research project. Founded in 2015 in Switzerland, the vendor’s market offering includes the LCDP product and application development services. The vendor employs around 30 people and its client base is formed mainly of Swiss and French clients. Interviewing employees from both strategic and operational levels gave us a holistic picture of the LCDP and its characteristics (Eisenhardt and Graebner, 2007). Moreover, all of our interviewees had close and regular interaction with the company’s clients and therefore broad knowledge on LCDP use in distinct projects, providing us rich insights into the platform’s use during innovative application development. All interviews took place in the vendor’s offices in a face-to-face setting and were recorded for transcription and coding afterwards.

N°	Date	Interviewee Role	Topic	Duration
1	May 14 <sup>th</sup> 2019	COO	LCDP characteristics and use during development	38 min
2	May 17 <sup>th</sup> 2019	Developer/Project Manager		48 min
3	May 21 <sup>st</sup> 2019	Senior Developer		45 min
4	May 21 <sup>st</sup> 2019	Account Manager		1h 6min
5	May 21 <sup>st</sup> 2019	Developer		58 min
6	May 21 <sup>st</sup> 2019	Platform Developer		35 min
7	June 4 <sup>th</sup> 2019	CEO		1h 25 min
8	June 6 <sup>th</sup> 2019	Executive VP of Sales and Marketing		25 min
9	June 7 <sup>th</sup> 2019	Product Manager		44 min
10	July 12 <sup>th</sup> 2019	Lead Developer		1h 7min

Table 1. Interviews

To gain rich descriptions of the LCDP and its use during the development of innovative applications, we chose to conduct semi-structured interviews, with an interview guide that we continuously adapted over the course of the interviews (Yin, 2014). We started each interview with a brief introduction of the study, after which we asked the participants to present themselves, by describing their current role and professional background, before guiding the conversation to the LCDP platform, its characteristics and use cases at different clients. Moreover, we asked the participants to describe project and team settings

they had worked in when using the platform and the platform's particular strengths and weaknesses during application development. Specialized knowledge quickly emerged as a central theme when developing applications on the LCDP which encouraged us to pursue our research question further.

In the second step of our data collection, we wanted to gain an even broader understanding of LCDPs and triangulate the initial observations we had from our interview data. We thus chose to complement our interview data with publicly available LCDP data of two types: (2a) LCDP product review data by LCDP users and (2b) LCDP related archival data from LCDP vendors and analysts. Drawing on such archival data which could provide us with insights from a range of users of a platform (e.g. citizen and professional developers, senior management, implementation partners, vendors etc.) is an approach that has been suggested for digital platform related research (De Reuver, Sørensen and Basole, 2018). To facilitate this data selection, we drew upon Forrester's LCDP product analysis which classifies LCDPs into two categories according to their main target user group: business developers (citizen developers) or professional/IT developers (Rymer, 2017b). With our primary aim being to understand how LCDPs can foster knowledge integration between the business and IT and therefore actively engage the business in the development process, we chose to restrict our analysis to the business developer oriented LCDPs. This resulted in the following 12 LCDPs being selected for further examination: Airtable, AppSheet, Betty Blocks, Caspio Bridge, FileMaker, Kintone, Kissflow, Quick Base, Scopeland, TIBCO Cloud Live Apps, TrackVia and Vinyl. While these platforms are primarily aimed at citizen developers, the IT function is still expected to play an active role in supporting and collaborating with citizen developers during the development of more technically complex elements and maintaining, controlling and owning the underlying platform. They therefore allowed us to gain some insight into the interaction between the business and IT while developing applications on LCDPs.

We collected the LCDP product review data (2a) from the Gartner Peer Insights portal (<https://www.gartner.com/reviews/home>) whose reviews are verified to come from genuine users who are evaluating the products based on their own user experience. Each review consists of the reviewer's overall comment about the product in question, together with answers to detailed questions for instance on the reviewer's favourite and least favourite aspects of the product and the organizational context in and frequency at which they used it. The reviewer profiles contain details such as the reviewer's role, seniority, organization size and industry.

An initial scan of the reviews revealed that all of the 12 vendors mentioned had received at least 2 reviews except for Scopeland which had not received any reviews. Scopeland was thus excluded from the rest of the analysis. Quick Base had a total of 213 reviews, relatively many more than any other vendor. To avoid overrepresentation of Quick Base, we chose to include 18 reviews, as per the average number of the reviews for the other products. This led to a total of 201 reviews being included in the analysis, as shown Table 2.

LCPD Product	Airtable	AppSheet	Betty Blocks	Caspio Bridge	FileMaker	Kintone	KISS-FLOW	Quick Base	TIBCO Cloud Live Apps	TrackVia	Vinyl	Total
Number of reviews	15	13	32	23	3	40	15	18*	2	11	28	201

Table 2. LCDP product review data (\*out of a total of 213)

Finally, we gathered archival data on LCDP (2b) from two sources: the analysts Forrester and Gartner and the 11 LCDP vendors mentioned above. From the former we included analyses and survey reports, whereas from the latter we included customer stories, commissioned survey reports, white papers and other texts such as blog posts and fact sheets. This data provided us with details about the selected LCDPs' functionalities and their typical use during application development. In total, we included 509 pages of LCDP related archival data from 56 analyst and vendor documents.

### 3.2 Data analysis

We used the Atlas.ti tool to manage our data and iterative coding process. In the first stage of coding, two of the authors coded the interview data and discussed resulting codes and initial observations extensively. The discussion centred primarily on the general sense of what was going on in the data (Elo and Kyngäs, 2008) and whether and how the concepts from knowledge integration fit the context of LCDP development. First, we observed that for instance the integration mechanism ‘rules and directives’ drew several parallels with mentions of LCDP development standards, conventions and guidelines, application templates and governance policies. This led to us developing an initial mapping of how the knowledge integration mechanisms would map into an LCDP context. This mapping of knowledge integration mechanisms and LCDP themes evolved during the coding process as we got more familiar with the data. The final mapping, together with examples from the data, is available in the Appendix. Second, we observed that multiple characteristics of LCDPs were often emphasized together with LCDPs’ use for innovation. This led to the tentative derivation of five categories of LCDP characteristics that we structure our results by in the following section. Following this initial stage, we coded the rest of the data, searching further elements that would corroborate our tentative findings from the interviews (Elo and Kyngäs, 2008), while remaining also open to any newly emerging codes and observations.

In sum, in line with the conceptual grounding of our study, our top-down code list was steered by the knowledge integration mechanisms by Grant (1996) and Alavi and Leidner (2001). These codes were combined with bottom-up generated codes relating to the LCDP context. In turn, the codes relating to the characteristics of LCDPs were generated bottom-up as we observed recurring themes in our data. This approach for generating the bottom-up codes was in line with the conventional content analysis approach discussed for instance by Hsieh and Shannon (2015), in that we immersed ourselves in the data and allowed for new categories to emerge. This was a particularly suited approach as knowledge and existing literature on the phenomenon of LCDP use for innovative application development is still limited. While the conceptual grounding of knowledge integration provided us with direction throughout the data analysis process, the knowledge integration mechanisms are at a higher level and had to be transposed onto an LCDP context by generating additional codes capturing the LCDP context.

## 4 Findings

In the following, we describe five key characteristics of LCDPs that emerged from our data and explain how LCDPs support the integration of specialized business and IT knowledge. The characteristics are organized according to the knowledge integration mechanisms they support, starting with rules and directions, followed by organizational routines and finally, group problem solving and decision-making.

### 4.1 Centralized structure

LCDPs provide a centralized platform for innovative application development, as IT owns and manages the platform, but provides citizen developers with access to application development. Highlighting the need for such centralized management by IT, the CEO of the LCDP vendor noted: “*Obviously you cannot let every guy at for example [client] build their own tool, you need to have some centralized management and that is part of [the LCDP]*” (interview 7, CEO).

**Knowledge integration through rules and directives:** LCDPs’ centralized structure supports the use of rules and directives as it gives IT the ability to communicate and enforce controls regarding application development. As an LCDP acts as a single point of contact for innovative application configuration and maintenance, architectural and development standards can be defined and enforced, for instance through application templates containing details on data sources, forms, integrations and logic. Our data highlighted the importance of having such architectural guidelines when first adopting an LCDP, with an admin of Quick Base for instance describing one of their organization’s lesson learnt as: “*Plan more and plan better. We built a lot of apps – apps that became mission critical – on the fly without a ton of planning or forethought. The end result of that was apps that became massive pains to administer in the*



long-term because we kept bolting things on, as opposed to planning out an architecture approach and sticking to it". Furthermore, LCDPs' centralized structure allows for access to be restricted to only users that have been provided sufficient training and instructions, for instance on data protection, security protocols and data sourcing. Specialized IT knowledge can thus be applied on LCDPs' centralized set-up and communicated to a wider audience in the form of templates, training and access rights provisioning.

## 4.2 Reusable development components

A distinguishing characteristic of LCDPs is their pre-programmed development components, also referred to as "Lego bricks" or "building blocks" which can be reused across applications. These building blocks can be of varying levels of technical complexity, ranging from rather simple blocks developed by a citizen developer to highly technical components (e.g. legacy integration components) developed by an LCDP vendor or the organization's IT staff. The components are held in a shared library embedded in the LCDP from where any user can drag-and-drop them into an application.

**Knowledge integration through rules and directives:** The reusable development components can be understood as 'containers' for IT to apply specialized IT governance knowledge into. Consequently, each development component contains morsels of specialized IT knowledge which can be further communicated to a wider audience of citizen developers by making the components available to them in a controlled manner. For instance, a block intended for sourcing data will provide data governance-related knowledge regarding the appropriate source system and fields to use for a particular type of data. As put by a CIO reviewing Vinyl: *"The platform is inherently focused on master data (has the ability to connect to any system) and does an excellent job enforcing data governance and quality in applications which collect key data inputs"*. This specialized IT governance knowledge is integrated with business knowledge as citizen developers combine these blocks to develop innovative applications.

## 4.3 Ease-of-mastery

A key characteristic of LCDPs is their low level of technical complexity which allows for them to be mastered easily by users with little technical know-how. While our data highlighted LCDPs' ease of use, it also emphasized that some time should be dedicated to learn platform-specific functionalities. This applied to both citizen developers as well as LCDP admins and could occur through formal training and/or playing around in a sandbox environment before starting any actual development tasks.

**Knowledge integration through organizational routines:** LCDPs' ease-of-mastery characteristic supports the formation of new organizational routines for developing innovative applications. More specifically, this characteristic enables citizen developers to form routines where they drive the early stages of application development without having to seek the support of IT or requiring large time and money investments from their superiors. Having the LCDP available to them, a business employee may start building an application as they encounter an issue in their daily work. In other words, the person with the knowledge can kick-start the build of an application without having to communicate their knowledge – consisting of both the application idea and the business context it is intended for – to others. As put by one of our interviewees: *"You can try your stuff on your own, and you know, you don't even have to be a developer for that. So, you have a need, you have the tools to solve the problem. Innovation will happen in that way, because people will be able to work on their ideas without having to involve ¾ of the company to get the resources that they need to do that"* (interview 6, platform developer). This is in contrast to the traditional process where the idea and related knowledge would be transferred to IT in the form of a formal requirements document. This implies that highly contextual and detailed business knowledge can be leveraged where it resides in the organization rather than transferring it to IT. The same interviewee specified further that this would allow an employee to directly apply their specialized knowledge to the application: *"you know what you want, so it's better if you are able to do it yourself to some extent and we'll provide you the heavy-lifting behind the curtains through the platform and that should get you there."* (Interview 6, platform developer). This was echoed by a sales and marketing manager using Quick Base who noted: *"I appreciate not having to engage IT every time I have a*

*business need, and IT appreciates my ability to take on some of my own work*". Having tried out an application idea, a citizen developer can engage with an LCDP power user or developer from IT for further development and scaling further down the line. Power users or IT can *"take over for Citizen Developers when they reach the limits of their knowledge (for example API integrations or other more technical feats), and help Citizen Developers optimize their platform skills"* (Betty Blocks, no date).

#### 4.4 Visual interface

A key characteristic of LCDPs is their visual user interface, often with a drag-and-drop functionality to build and preview applications during development. The visual interface supports group problem solving and decision-making between business and IT specialists.

**Knowledge integration through organizational group problem solving and decision-making:** The CEO and founder of the LCDP vendor explained his original motivation for developing the platform as an aspiration to transform the traditional development process where employees from the business describe their requirements to developers in documentation form and whose outputs rarely meet the original requirements due to misunderstandings or knowledge gaps. The CEO's intention was to make the actual process of application development engaging and more inclusive rather than occurring behind closed doors. In particular, their intention was to make application development inclusive of employees from business units who held in-depth business knowledge instead of deep technical knowledge and coding skills. They explained: *"That's the way it started in my head about [the LCDP]. It was really, let's lower the barrier to create software so that these guys in the field can participate in the software development"* (Interview 7, CEO). The LCDP vendor Kintone echoes this view very closely with: *"Low-code solutions like Kintone enable business professionals to build applications visually and get them deployed fast—lowering the barrier of entry for application development"* (Kintone, 2016). Another interviewee explained how this participation is aided by the visual interface: *"One of the strengths of [the LCDP] is that there is a screen and, even if the user doesn't know how the programme is built, he sees the screen. There are two parts: the back end – the core data model – and how it is described: with diagrams. So, we can show both worlds and put them together. Even the user can understand why he can't have a given piece of information, because it's not in the model. So, this helps everyone understand how it's done"* (interview 3, senior developer). The interviewees highlighted particularly the visual interface's convenience when physically co-located in the same space, such as a meeting room.

#### 4.5 Real-time editing

LCDP functionalities can be added and discarded quickly with the changes being visible directly on the application as they are made. As with the visual interface characteristic above, real-time editing facilitates group problem solving and decision-making.

**Knowledge integration through organizational group problem solving and decision-making:** As one of our interviewees explained: *"with [LCDP] the real advantage is that every team member of the client -either the designer, either the user or whoever- we can do a workshop with them directly on the platform, so they already have a clear view of what we will be building, because well, we are doing it live in front of them and we can discuss it more smoothly. So, for example, I build a thing and they can give me feedback just right now, we don't have to write it down, go back in our office, build the programme, show them, [but] we can do it live so we get the feedback from them more quickly. We can bring different teams together so they really themselves see how the programme is built, what is linked to what."* (interview 3, senior developer). The LCDP has therefore the ability to bring together a set of diverse actors and allow for rich interactions which result in the integration of specialized knowledge as applications can be discussed and quickly edited, with each change visible in real-time. Another interviewee drew on his experience during a recent project when he noted that the LCDP was particularly valuable when bringing together business employees with in-depth specialized domain knowledge and professional developers. The LCDP's real-time editing allowed *"them to have a common language and thus more quickly identify the functionalities that are needed to build an application that adds value"* (interview 10, lead developer).

## 5 Discussion

Our study's main aim is to understand how LCDPs can support knowledge integration between the business and IT during innovative application development. In this section, we examine how the LCDP characteristics we uncovered in the previous section link to the knowledge integration mechanisms introduced by Grant (1996) and further discussed by Alavi and Leidner (2001). We formulate three propositions (P1-P3) accordingly, as outlined below and summarized in Figure 1.

*P1: LCDPs' centralized structure and reusable development components support knowledge integration through rules and directives.*

LCDPs' centralized structure and development component reusability support the use of rules and directives. The former allows for the LCDP to act as a single point of contact for application activities, whereas the latter allows for morsels of knowledge to be applied and reused across innovative applications. In particular, reusable development components can minimize communication regarding for instance data sourcing, forms, integration and other logic that can drive standardization across applications. The two characteristics thus allow for the implementation and continued enforcement of governance policies and development standardization. Governance policies and standardization align with rules and directives which Grant (1996) sees as a "low cost method of communicating between specialists and the large number of persons who either are non-specialists or who are specialists in other fields" (p. 114-115). In this way, LCDPs enable the IT unit to effectively communicate the rules and directives by which application development should be done to a group of people who are specialists in another domain, namely citizen developers and the business. Although the use of rules and directives for knowledge integration may seem counter-intuitive in this age of co-creation and collaboration, we suggest that LCDPs can support rules and directives' use in a subtle manner where they implicitly direct citizen developers' activities rather than being imposed as an explicit guideline. In terms of innovation, however, LCDPs' reusable development components can be a double-edged sword in that they both enable, but also restrict what a citizen developer can do. As put by a Betty Blocks user: "*On the one hand I really liked [the Betty Blocks platform], the possibility of developing very quickly without writing code is very interesting. But on the other hand, I do not feel comfortable, as if somehow my app has to adapt to the platform and not vice versa*". Whilst they can therefore aid knowledge integration, they may introduce a harmful side-effect in terms of slowing down or even stopping the development of innovative ideas if the required blocks are not available.

*P2: LCDPs' ease-of-mastery supports knowledge integration through organizational routines.*

Organizational routines are supported by the ease-of-mastery of LCDPs as citizen developers are able to initiate the development of an innovative application. They may try out their idea first of all and only engage the IT unit (and other specialists) once they deem their idea to have enough potential to pursue full-scale development which requires a more extensive set of specialized knowledge. Once they do engage others in the development process, they can demonstrate and communicate their idea thoroughly and concretely, together with areas that require further input and specialized knowledge, for instance from developers in terms of developing more technical blocks or from designers to give the application a look that is consistent with the organization's branding. In this way, LCDPs allow for individuals that hold distinct types of specialized knowledge to get involved in the development in a sequenced manner when their input is required. Ease-of-mastery therefore primarily enables the citizen developer to kick-start development without having to communicate their specialized knowledge to others. In other words, specialized business knowledge can be leveraged where it resides in the organization rather than being transferred from one function to another, namely from the business to IT. More generally, this implies the shifting of some development activities from the IT unit out to the business.

*P3: LCDPs' visual interface and real-time editing support knowledge integration through group problem solving and decision-making.*

Our findings suggest that LCDPs' visual user interface provides the business and IT with a common view and language during the development process. It facilitates working in cross-functional teams consisting of individuals with specialized knowledge as the visual canvas provides a common view for all.

Together with real-time editing, the visual interface provides a basis for rich interactions and collaborative working as changes can be observed, discussed and decided upon jointly. As summarized by an interviewee: “That’s what I actually liked about [the LCDP] is that even during the development you can actually involve people and for instance the business analyst can actually open [the LCDP] and make the business model. Then the UX or UI guys can come and start building the screens and it’s not like a traditional development process where you have the specifications and then you have to implement them. [With the LCDP] you don’t have to waste time to take this transfer step” (Interview 5, developer). LCDPs’ visual interface and real-time editing characteristics therefore primarily support the combination of both specialized IT and business knowledge through group problem solving and decision-making. In line with this, an LCDP developer survey conducted by Forrester finds that LCDP development tends to take place in larger teams that traditional development, with five or more members in a typical LCDP development team (Rymer and Seguin, 2019b).

Our data’s emphasis on knowledge integration through group problem solving and decision-making during application development aligns with the growing trend of using cross-functional and self-organizing teams, in particular for projects with high uncertainty and complexity (Fitzgerald *et al.*, 2014). On the other hand, however, co-creating applications in meetings with numerous participants can drive up application costs and quickly outdo the savings made from faster application development. The growing trend of remote working also puts physically proximate group problem solving and decision-making into question.

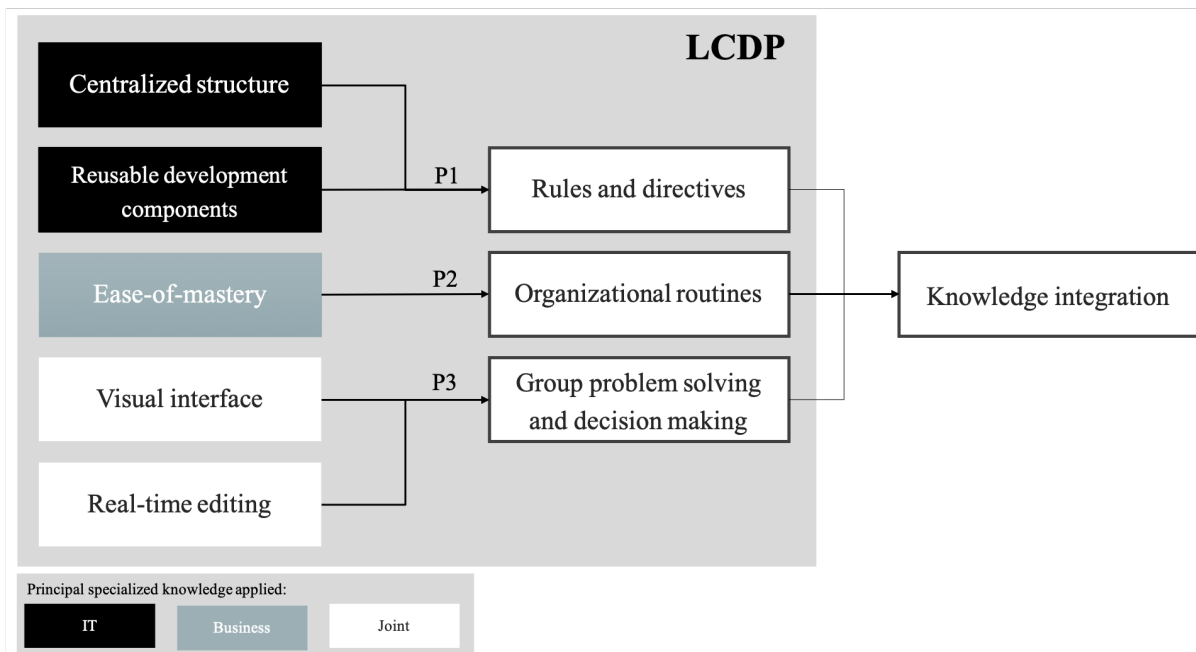


Figure 1. LCDP characteristics and knowledge integration mechanism propositions

Although our propositions have delineated the characteristics of LCDPs and linked them with specific knowledge integration mechanisms, we note that the characteristics are closely entangled, with all of them jointly and cumulatively allowing for the emergence of knowledge integration. For instance, *ease-of-mastery* enables a citizen developer to perform the initial stages of an application’s development in an uninterrupted manner and with minimal involvement of others. In conjunction, as the citizen developer performs these initial development steps, they use the LCDPs’ reusable development components, and consequently combine their in-depth business knowledge with technical knowledge captured in the development components, ultimately resulting in knowledge integration. Overall, LCDPs acts as an operant in the innovation process (Nambisan, Wright and Feldman, 2019) by acting as a linking pin to both citizen developers and IT professionals and consequently, the specialized knowledge of each group. On the one hand, this implies that the early stages of application development may shift from IT unit to

business units, while, on the other hand, it implies a closer collaboration between the two units. LCDPs thus hold potential for changing existing development practices on a broader scale, contributing to the changing role of the IT function due to new digital technologies (Urbach, Drews and Ross, 2017).

It is worth noting that while citizen development may enhance enthusiasm for digitalization across an organization, potential pitfalls include an abundance of localized applications being developed without an end-to-end view of whole business processes and a coherent strategy (Rymer, 2017a; Osmundsen, Iden and Bygstad, 2019). While LCDPs may therefore support knowledge integration, without a coherent strategy and governance mechanisms their benefits may remain localized and limit the contribution to the building of an organization's overall innovation capability. Defining and communicating a governance policy to all users is also coupled with basic training that is still needed when adopting an LCDP. Specifically, both prospective IT and citizen developer users should be trained on the platform's functionalities and surrounding processes. While the training for citizen developers should not enable them to write code and program in the traditional sense, it should provide them with the foundations of application development in terms of process and conceptualizing. With such a holistic approach, LCDPs can support or generate innovative behaviors among individual citizen developers.

Finally, although our study provides comprehensive initial insight into how LCDPs may support bringing together valuable knowledge from disparate parts of an organization, we recognize three main limitations. First, our primary data was limited to ten interviews at a single site playing a specific role in the LCDP market (i.e., a vendor) which restricts the generalizability of our results and could contain underlying biases. We however aimed to compensate for this by supplementing the interview data with publicly available LCDP review and archival data. This approach for leveraging publicly available data was in line with De Reuver, Sørensen and Basole's (2018) methodological suggestion for researching digital platforms with multiple stakeholders. Having followed this suggestion, we are of the opinion that the review and archival data not only served its purpose for triangulating the interview data but also provided us with valuable additional insight into how and by whom LCDPs are used in distinct organizational contexts. In terms of potential commercial biases resulting from using data from LCDP vendors, Forrester recently noted that LCDP users are relatively satisfied with the LCDPs they use (Rymer and Seguin, 2019b), suggesting that vendors are at least to some extent able to deliver on their promises, thus giving us some confidence in their material and reported use cases. Future research may focus on validating and further developing our propositions, drawing on primary data from an organization using an enterprise wide LCDP solution. We anticipate such research sites to become more readily available as more organizations adopt LCDPs and the already existing LCDP solutions mature. Second, LCDPs are still an evolving technology and, as with any technology product, variation exists among the products offered by different vendors. Analyzing a total of 12 LCDPs however gives us confidence that the characteristics we identified are overarching enough to be described as key characteristics of LCDPs primarily targeted to business users. Third, the scope of this paper has focused on internal knowledge integration only, excluding LCDPs' potential for external organizational knowledge integration. We highlight external knowledge integration (for instance through LCDP product community forums and public reusable development components rather than just private ones that have been considered in this paper) as an avenue for future research, as also highlighted by recent knowledge integration research relating to digital innovation (Zapadka, 2020) and the growing prominence of concepts such as dynamic capabilities (Kump *et al.*, 2019).

## 6 Conclusion

In most firms, business units have traditionally been discouraged from tinkering with application development and instead encouraged to capture their needs in formal requirements documents to be reviewed and implemented by IT behind closed doors. The profound differences in knowledge, culture and ways of working between business and IT units have contributed to this knowledge transfer logic being the preferred process. In this day and age, however, this process often results in inefficiencies during application development as essential specialized knowledge resides in disparate locations across the organization. These inefficiencies are particularly evident for new, innovative applications whose requirements

are fuzzy and only become clearer with an iterative and experimental development process. The growing imperative for ongoing innovation in the digital world thus calls for more efficient ways to bridge the business-IT gap.

In this qualitative study, we find that LCDPs can support business and IT units to integrate – rather than transfer – their specialized knowledge. We suggest that the characteristics of LCDPs can foster knowledge integration via mechanisms previously identified by organizational and IS scholars. Using LCDPs as a practical illustration, we show how new digital technologies can play an increasingly operant role in innovation (Nambisan, Wright and Feldman, 2019) by allowing for knowledge to be acted upon where it resides in the organization rather than being transferred from one unit – business – to another – IT. We also demonstrate how traditional knowledge integration mechanisms may still remain valid even in the context of digitalization.

As centralized IT functions are struggling to meet expectations placed on them and retain control of increasingly democratized IT development within organizations (Gregory *et al.*, 2018; Leonhardt, Hanelt and Kranz, 2020), LCDPs can provide a linking pin for citizen developers from across the organization whose inputs are, on the one hand, needed for developing value-adding innovations but whose activities, on the other hand, need to a certain extent also be controlled and governed. We do not suggest that adopting an LCDP will be a panacea to all application development or innovation related challenges today's organizations are facing. Rather, we suggest an LCDP can support harnessing and integrating existing knowledge from disparate organizational pockets and, as any technology, should be coupled with an appropriate governance policy and strategy. Our overall aim with this paper is to provide a basis for discussions on LCDPs' potential in supporting knowledge integration and consequently, an organization's innovative capability. Additional research on LCDPs' role in supporting innovation is necessary as LCDPs become more widely adopted and already existing instantiations mature.

## 7 Appendix

Knowledge Integration Mechanisms (Alavi and Leidner, 2001)	Corresponding LCDP themes observed in the data	Example quotes from the data
<b>Rules and directives</b>	Governance	"Users build and deploy all apps on managed platforms, opening opportunities for Application Development & Delivery organizations to influence, support, and even control the efforts of business developers." (Forrester) "Through getting acquainted with the platform on a deep level, your IT pros and no-code developers will learn more about which roles and authorizations they want to delegate to Citizen Developers and which they want to limit access to. This training should provide an opportunity for the IT department to discuss how governance and data access will work and lay out a plan." (vendor whitepaper)
	Development conventions, standards, templates	
	Policies relating to application build	
	Training	
	Access and authorizations	
<b>Organizational routines</b>	Monitoring and controlling	"You can try your stuff on your own, and you know, you don't even have to be a developer for that. So, you have a need, you have the tools to solve the problem and so innovation will happen in that way, because people will be able to work on their ideas without having to involve ¼ of the company to get the resources that they need to do that" (interview 6) "I appreciate not having to engage IT involved every time I have a business need, and IT appreciates my ability to take on some of my own work" (product review)
	Development process	
	Autonomy from IT, citizen developer self-sufficiency	
	Shifting development tasks from IT to citizen developers	
<b>Group problem solving and decision-making</b>	Split of responsibilities between business (citizen developers) and IT	"We can bring different teams together so they really themselves see how the programme is built, what is linked to what." (interview 3) "The key to success is multidisciplinary teams in general, and close collaboration with IT specifically. Organizations where the IT department assumes responsibility for the sanctioned use of a platform on which citizen developers can work, there should be multidisciplinary teams of both IT professionals as well as business liaison officers to make the initiative a success." (vendor whitepaper)
	Small teams	
	Large teams	
	Cross-functional teams	
	Co-creation, close collaboration IT-business	
	Physical proximity during development	

Table 1. Coding scheme and mapping for knowledge integration in an LCDP context

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