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Advancing social practice understandings of digital innovation delivery in construction project management

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Abstract:	

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Manuscripts

1 Advancing social practice understandings of digital innovation delivery in construction
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6 2 project management
7

8 **Abstract**

9 **Purpose**

10 The paper applies social practice theory to clarify the process of innovation design and delivery
11 from one successful digital innovation: the BIM risk library. The paper clarifies the practices
12 surrounding construction innovation and provides a schema useful for practitioners and
13 technology designers through a social practice analysis.
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10 **Design/methodology/approach**

11 The paper applies Schatzki's 'organisation of practice' concepts to a construction project
12 innovation to clarify how the practice of innovation revolves around understandings, rules and
13 teleoaffectivities (emotive behaviours). Sources for the study include notes from meetings,
14 workshops with experts and the shared artefacts of innovation.
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16 **Findings**

17 The practice of innovation design and delivery are clarified through a social practice analysis:
18 a distinct "field of practice" and a "schema" of generalizable prescriptions and preferences for
19 innovation delivery being presented.
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21 **Originality**

22 The social practice analysis of one successful construction innovation is an original
23 contribution to the body of knowledge, adding a level of detail regarding innovation design and
24 delivery often missing from reported research.
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3 26 **Practical implications**
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5 27 The paper informs the practice and process of innovation design and delivery; the insights
6
7 28 clarify how collective understandings and rules of use evolve over time, becoming formalized
8
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10 29 into contracts, agreements and workplans. Practically, processes whereby innovation ‘sayings’
11
12 30 evolve into innovation ‘doings’ are clarified: a schema detailing prescriptions and preferences
13
14 31 of practitioners and developers being presented.
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18
19 33 **Keywords:** innovation studies; BIM; building information modelling; digitalisation; projects-
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21 34 as-practice; social practices; health and safety; data engineering.
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51 Introduction

52 Managing an innovation is as important as the innovation development process itself (Bamel
53 et al. 2023); construction project management innovations being interventions into existing
54 complex working practices (Liu et al. 2018). As such, aligning an innovation to those practices
55 to minimise disruption and continue business-as-usual processes is important. Additionally,
56 the process of innovation adoption whereby an innovation becomes part of everyday project-
57 based working practice remains unclear: innovation adoption being a complex business, with
58 little to guide practitioners through the messy and contingent process of adoption and diffusion
59 (Harty, 2005). Therefore, understanding how innovations are delivered is important for
60 improving innovation practice itself (Havenid et al. 2019). Whilst Winch (1998) notes that
61 more case studies of trajectories of innovation are required in order to identify who generates
62 new ideas and how they are managed into “good currency”, the process of innovation design,
63 prototyping, testing and deployment requires a theoretical and conceptual unpacking using
64 empirical evidence. This paper makes a contribution by examining how one successful digital
65 innovation was developed and deployed with several project-based organizations to become
66 part of their everyday working practices. The innovation (the BIM Risk Library) was recipient
67 of several industry awards (buildingSMART, 2020; Construction Computing Award, 2021)
68 and therefore provides valid data regarding a “successful innovation”. Amongst the key
69 questions posed by the paper are: what contributes to successful innovation deployment in
70 construction project management? What are the drivers and inhibitors of successful innovation
71 delivery? How can the innovation delivery process be conceptualised and understood?

72
73 The paper adopts a projects-as-practice (Blomquist et al. 2010) approach and uses social
74 practice theory (Schatzki, 2001) to review the process of innovation delivery. The case for
75 adopting a projects-as-practice approach for understanding what occurs on projects has been

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3 76 made for some time (c.f. Koch et al. 2019; Blomquist et al., 2010; Clegg et al. 2018). In
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6 77 outlining a projects-as-practice approach to conducting research in project management,
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8 78 Blomquist et al. (2010) note that project management is an immature field of research, where
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10 79 many of the normative and traditional contributions are insubstantial when it comes to
11
12 80 understanding what is really occurring in projects (see Winter et al. 2006). Clegg et al. (2018)
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14 81 argue that practice-based research provides a methodological lens to explore the reality of
15
16 82 project management work; the authors noting that practice-based perspectives are under-
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18 83 represented in project portfolio management (PPM) research, whilst presenting an agenda for
19
20 84 further practice-based research, including its discursivity, representation, dynamic capabilities,
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22 85 leadership and materiality. This paper follows this tradition by employing a “social practice”
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24 86 theoretical perspective to established frameworks for innovation diffusion; the framework of
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26 87 Steiber and Alänge (2015) being a foundation upon which a social practice analysis of
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28 88 processes and interactions may be overlaid.
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33 89 The paper adopts a granular analysis of the interactions between innovation stakeholders to
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35 90 identify the concepts characterizing a ‘practice of innovation delivery’ that pivot around rules,
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37 91 understandings and teleoaffectivities (emotive behaviours). The analysis of the work around
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39 92 one successful digital innovation (the BIM Risk Library) leads to identification of specifiable
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41 93 enacted schemas (i.e. practitioner preferences and generalizable procedures) to be addressed
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43 94 by innovation developers. As a result, the practice of innovation delivery in construction
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45 95 contexts is noted to be distinctive and governed by specifiable preferences and prescriptions
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47 96 (Knorr Cetina, 2001): understanding construction working practices and aligning an innovation
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49 97 to those practices being critical for successful innovation design and deployment. The
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51 98 originality of the work arises from the analysis of each step of the innovation design and
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53 99 delivery process and its’ associated artefacts using Schatzki’s practice theory concepts. The
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100 contributions which result, around sayings, formalisations, doings and a schema for innovation
101 delivery add to the body of knowledge concerning construction project innovation.

102 The paper is organised as follows. A literature review scopes out understandings of the practice
103 of innovation delivery in construction, identifying gaps in knowledge and issues requiring
104 clarifications. The projects-as-practice literature and social practice theory of Theodore
105 Schatzki are then presented to provide theoretical orientation and foundation. A methodology
106 section describing the research approach adopted is followed by presentation of the innovation:
107 the BIM risk library: a collaboration between University of Manchester (UK), the UK regulator
108 for workplace health and safety (the Health and Safety Executive – HSE), several construction
109 companies and a building information modelling (BIM) software provider. The high-level
110 review of innovation development work is complimented by deeper analysis of the
111 collaborative agreements between partner organizations and data management workflow
112 employed for innovation data harvesting and development. Collectively, this evidence distils
113 the ‘field of practice’ (Schatzki, 1996) of innovation delivery in construction with an “enacted
114 schema” for innovation delivery coming into focus from the analysis. A following discussion
115 notes how the social practice findings align and enhance the framework of innovation diffusion
116 of Steiber and Alänge (2015): innovation evolution being understood in social practice terms,
117 with a schema for innovation delivery and relations between “sayings”, “formalisations” and
118 “doings” being presented. A closing conclusion draws the insights of the paper together.

119

120 **Understanding the Practice of Innovation Delivery**

121 Recent published work regarding innovation in the construction industry has addressed a
122 variety of subjects, including the effect of supply chain innovation on competitive advantage
123 (Afraz et al. 2021), open innovation and the enhancement of productivity (Greco et al. 2021),
124 innovation ecosystems and collaboration in infrastructure projects (Vosman et al. 2023) and

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3 125 boundary-spanning for managing digital innovation in the AEC sector (Azzouz and
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5 126 Papadonikolaki, 2020). Whilst these contributions have added to the body of knowledge
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7 127 concerning innovations in construction, there remains a need to understand the practice of
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9 128 innovation delivery. In this respect, whilst diffusion of innovations across firms has been
10
11 129 recognised as a non-linear process (Shibeika and Harty, 2015), research has also examined how
12
13 130 companies organise for digitalization (Morgan, 2019). However, understandings of the
14
15 131 practice of innovation delivery are opaque and ambiguous: understanding the trajectory of a
16
17 132 digital innovation (Winch, 1998), and how an innovation transforms from research idea to a
18
19 133 fully-fledged application being much less understood. It has been noted that the relationship
20
21 134 between system developers and potential industry users can be contentious (Liu et al. 2018),
22
23 135 with challenges towards industry uptake of innovations being considerable (Oesterreich and
24
25 136 Teuteberg, 2016). Whilst technical, practical and social barriers to innovation uptake are
26
27 137 commonly evident (Collinge et al. 2020a), Blindenbach and Van Den Ende (2010) note that
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29 138 project-based firms have more difficulty innovating products, services and operations as
30
31 139 compared to when they innovate for their clients. As a result, suitable engagement strategies
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33 140 and appropriate working relationships with technology developers need to be established.
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35 141 Blindenbach and Van Den Ende (2010) also note that the effects of specific management
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37 142 practices on project performance are different, particularly the effects of planning,
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39 143 multidisciplinary teams and heavyweight project leaders. The authors note that differences in
40
41 144 firm characteristics provide an explanation for the findings; an implication for the innovation
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43 145 management literature being that “best” practices for innovation management are firm
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45 146 dependent. Söderlund (2004) points out that process and real-time case studies and project
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47 147 organization issues are of particular interest, and therefore analysis of exemplar “successful”
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49 148 innovations can provide the empirical data needed for such studies.
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3 149 Cicmil (2006, p. 36) asserts that project theory would be served by a qualitative approach with
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5 150 a critical interpretive lens that might 'generate alternative understandings of what goes on in
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7 151 project practice and how practitioners participate in and manage complex organizational
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9 152 arrangements.' Consequently, examination of what people do in project contexts is a valid
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11 153 analytical approach rather than a confirmation of best practice models for project management
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13 154 (cf. Geertz, 1973). This aligns with Blomquist et al. (2010), who argue for a practice
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15 155 perspective (Schatzki, Knorr Cetina, & von Savigny, 2001) that begins with individual actions
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17 156 and asks what overall models and concepts result from those actions.
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22 157 Practice theory has been used to study interactions in construction project management
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24 158 contexts previously, for example to understand digital integration of built-environment
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26 159 practices (Çıdık et al. 2017) and collaboration in construction (Connaughton and Collinge,
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28 160 2021), but epistemological and ontological uncertainty remains, particularly regarding the
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30 161 delivery of innovations in construction project management. For example, whilst Bresnen
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32 162 (2009) argues that a 'practice' perspective allows us to focus on what happens in actuality:
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34 163 understanding practices being potentially more informative than industry-wide models of ideal
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36 164 processes, Marshall (2014, p.110) notes that practice theorists often fail to provide empirically
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38 165 sound demonstrations of theoretical propositions in action, thus limiting the usefulness of ideas.
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41 166 For example, the practice theory objective to clarify the emergent and ongoing constitution of
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43 167 social orders and change through situated practices has not been substantially engaged with.
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45 168 Similarly, whilst Blomquist et al. (2010) propose a 'project-as-practice' approach for
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47 169 understanding the complexities of working practices occurring in projects, noting the specific
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49 170 challenges for the researcher, O'Keeffe et al. (2015) comment that it is the 'doing' and
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51 171 'performance' that should be the basis of analysis in practice theories when stating,
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53 172 'Practice theory refocuses attention on the social nature of organized activities and how these
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55 173 relations are mediated by the materialities within which they become enmeshed.' (p. 416). This
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3 174 paper directly addresses the comments of Marshall (2014) and O’Keeffe et al. (2015) above by
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5 175 providing an empirical demonstration of practice theory concepts in action, and by highlighting
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7 176 the “doing” and “performance” of innovation practice in a construction context.
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12 178 Whilst the above reflections highlight the importance of empirical evidence for informing
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14 179 theoretical understanding of practices, in terms of models of innovation, important work has
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16 180 already been conducted in the field. Rogers (1995) notes six innovation-characteristics that
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18 181 matter for its diffusion in a social system; these being: its relative advantage for the adopter, its
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20 182 compatibility with the pre-existing system, its complexity or difficulty to learn, its testability,
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22 183 its potential for re-inventions, and its observed effects. Building on the work of Rogers, Steiber
23
24 184 and Alänge (2015) present an analytical framework for diffusion of innovations (figure 1). The
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26 185 framework includes five steps that a firm goes through when searching for, adopting, and
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28 186 implementing either a technical or organizational innovation: the five steps being desirability,
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30 187 feasibility, first trial, implementing, and sustaining. These five steps are in turn dependent on
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32 188 a firm's organizational improvement trajectory, which is cumulative and path-dependent due
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34 189 to increased return on investment on existing innovations, as well as on internal inertia among
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36 190 board members, top managers and employees. The five steps are all subject to three sets of
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38 191 influencing factors: characteristics of the innovation, the internal context, and external context
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40 192 (that include diffusion mechanisms).
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49 194 [Figure 1]

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54 196 In figure 1, the five steps are visualized as a circular pattern around an organizational
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56 197 improvement trajectory. The framework of Steiber and Alänge (2015) provides a validated
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58 198 model for the digital innovation delivery process by which activities could be analysed or
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3 199 planned. More recently, Steiber et al. (2021) explored the digitization process for industrial
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5 200 firms, presenting a validated framework based on innovation diffusion theories and case study
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7 201 evidence, with inhibitors and drivers of digital transformation being identified. As Steiber et
8
9 202 al. (2021) note, diverse theoretical perspectives and new research methodologies are needed in
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11 203 order to understand the major challenges that block or hinder firms' deployment of digital
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13 204 technologies. These insights reveal how there remains a need to understand the practice of
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15 205 innovation in clearer terms.
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22 207 **Social Practice Theory**

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25 208 Theodore Schatzki's social practice theory (1996; 2002) enables a domain to be examined as a
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27 209 'field of practices' with ever evolving 'nexuses of doings and sayings' (Schatzki, 1996).
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29 210 Although Schatzki (2001) notes that practice can refer to both individual performed activities
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31 211 and a guiding principle for activities, Knorr Cetina (2001) observes that the majority of scholars
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33 212 agree with the definition of practices as:

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37 213 'recurrent processes governed by specifiable schemata of preferences and prescriptions'
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39 214 (p.175)
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43 216 Schatzki's theory of practice (1996; 2002) is generally considered as one of 5 current
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45 217 approaches to studying practice (other approaches being communities of practice; activity
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47 218 theory; ethnomethodology and discourse analysis: Nicolini, 2012). Nicolini (2012) encourages
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49 219 researchers to draw selectively on concepts from different approaches to illuminate various
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51 220 aspects of practice, proposing a "toolkit approach" for empirical work. Such flexibility makes
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53 221 practice theory a potentially attractive methodological approach, whilst also remaining
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55 222 challenging. As Schatzki (2012) comments,
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3 224 'The world according to practice theory offers much to investigate. There are practices,
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5 225 arrangements, activities, bundles and constellations. There are questions about which of these
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7 226 exist, when and where, their details, how they work and unfold, how they can be designed or
8
9 227 altered, and how to prepare people to enter them.' (p.23)

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14 229 Schatzki (1996) maintains that practice is a "temporally unfolding and spatially dispersed
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16 230 nexus of doings and sayings, embracing notions of activity and organization" that make up
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18 231 people's "horizons of intelligibility" (Nicolini, 2012). Caldwell (2012) maintains that
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20 232 Schatzki's ambition is to ensure practices are ontologically more fundamental than language
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22 233 and discourse: practice actions (the "*doings*") taking priority over practice language (the
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24 234 "*sayings*"). Consequently, Schatzki gravitates toward a concept of agency as "doing",
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26 235 underplaying the role of language and discourse (Schatzki, 2002); in this scheme verbal and
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28 236 non-verbal signs are part of the "doing" of a practice rather than its principal components.
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30 237 Schatzki therefore distances his theory from those of Bourdieu and Giddens by rejecting
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32 238 Bourdieu's concept of "habitus" and Giddens concept of "practical consciousness" (Caldwell,
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34 239 2012).

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36 240 Whilst practice theorists generally maintain the social as a field of embodied, interwoven
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38 241 practices organised around shared practical understandings, the concept of "*field of practice*"
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40 242 or "*site of the social*" (Schatzki 2001) distinguishes Schatzki's theory from those of others (c.f.
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42 243 O'Keefe et al., 2015; Nicolini, 2012). This notion can best be described as the *context* within
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44 244 which practices occur: a "fields of practice" analysis being one that: a) develops an account of
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46 245 practices and/or b) treats the field of practice as the place to study the nature and transformation
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48 246 of their subject matter. This ontology comprises an array of orders and arrangements of people,
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50 247 artefacts and entities that constitute the organized activities of that place (Schatzki, 2001): the
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248 practices within a context being made explicit to identify the “practice-arrangement bundles”
249 of which those practices are part (O’Keeffe et al. 2015). As Schatzki (2013) states:

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251 ‘The coalescence of a practice involves some combination of (1) the emergence of common
252 rules (explicit formulations) in the light of which actors proceed, (2) the crystallization of sets
253 of prescribed or acceptable ends, tasks and actions, (3) the development of common practical
254 understandings, and (4) the distillation of common general understandings.’ (p.37)

255

256 With a social practice approach, examination of the digital innovation experience cannot be
257 understood separately from its’ context: that context being a “field of practices” within which
258 the innovation resides. As stated earlier, there is value in clarifying what constitutes a
259 supportive context for delivery of an innovation. Schatzki’s classifies the ‘organization of
260 practice’ into 4 concepts (Table 1).

261

262 [Table 1]

263

264 Referring to Table 1, an action belongs to a practice if it expresses one of the understandings,
265 rules or teleoaffective concepts that organize that practice, with activities forming a nexus in
266 that they are organised and connect together through such relations as causality and intentional
267 directedness (Schatzki, 2012, p.15). Of the above concepts, teleoaffectivities may be the most
268 difficult to conceptualise. It is best understood by conceding that separate practices possess
269 their own sets of acceptable and enjoined intentions, actions, emotions and moods (Schatzki,
270 1996, 101). In construction, intentions or goals are often influenced or directed by normative
271 and emotional behaviour (Caldwell, 2012, 290), with certain teleoaffectivities being associated
272 with specific practices. For example, a project team may express surprise and shock at a

273 supplier quote five times above the going rate. Teleoaffectivities are those emotions, moods
274 and actions that become associated with certain practices.

275
276 For an innovation, teleoaffectivities (i.e. positive or negative reactions) are potentially
277 significant to the success or failure of the innovation. For example, surprise and joy at being
278 able to perform a task not previously possible would be a positive teleoaffectivity, whereas
279 frustration or confusion about innovation use would be a negative teleoaffectivity. Therefore,
280 developers must be aware of teleoaffectivities and build-in processes to ensure possible
281 negative reactions are mitigated. This can be done via engagement activities, workshops and
282 pre-piloting work.

283
284 Schatzki (2002) also states that “human agency must be understood as something contained in
285 practices” (i.e. as the performance of doings and sayings that constitute the actions that
286 compose practices” p.240). Similarly to Schatzki, Sewell (1992), a practice theory scholar,
287 understands practices as enacted schemas (i.e. generalizable procedures) that can be transposed
288 from one domain to another, but that also organise and constrain other schemas. This paper
289 takes forward these ideas and Schatzki’s ‘organization of practice’ concepts to investigate the
290 practice of digital innovation delivery on the BIM Risk Library.

291

292 **Methodological Approach**

293 *Theoretical Positioning*

294 Theoretically, the research may be categorised as “social-science based” and “process-
295 oriented” rather than “engineering-focused” research (see Blomquist et al, 2020, p.6). As a
296 ‘theories-in-use’ contribution (Söderlund, 2004), the focus on project processes enables a
297 theory and its` associated concepts to be applied and examined objectively. In this case, the

298 paper applies social practice theory and the concepts of Schatzki (Table 1) to understand the
299 process of innovation delivery, such an analysis taking into account the complexities of human
300 life (c.f. Cicmil and Hodgson, 2006, p.10). Such an examination of social processes at work
301 (i.e. how understandings, emotions and rules emerge, evolve and become formalized) addresses
302 the need for more fine-grained studies of the microactivities occurring, as noted by Blomquist
303 et al. (2010, p.7). Methodologically, this paper follows the lead of O’Keeffe et al. (2015) in
304 focusing upon the “doing” or “performance” of innovation, and the processes leading up to
305 such “doings” in a construction project management context.

306 *Practical Details*

307 Practically, in terms of methodological steps, figure 2 presents the overall flowchart of work
308 from the BIM Risk Library project. A series of ‘legal artefacts’ associated with phases of work
309 activity are also highlighted: these legal artefacts being critical to the mobilisation of the
310 innovation. Methodologically, to conduct a social practice analysis of the work occurring, each
311 separate work activity was examined by the researcher using the ‘organization of practices’
312 concepts of Schatzki (1996) (Table 1). This meant identification of how rules, understandings
313 (both practical and general) and teleoaffectivities (emotive behaviours) manifested through
314 spoken dialogue, shared artefacts and plans of action to be taken forward. Sources of data
315 included notes from meetings, the workshops with industry practitioners that captured thoughts
316 and reactions to the innovation by industry experts, and the shared artefacts that played
317 prominent roles in the innovation design and delivery journey (i.e. collaborative agreements;
318 data management workflow; user guide; software tool). The multiple meetings between
319 research team and industry partners were recorded on a Trello board, providing a further source
320 of data. As will be noted, the shared artefacts, such as the collaborative agreements and data
321 workflow formalised how the innovation would operate and function. A post-pilot survey of
322 practitioners and interviews with individuals provided a further source of data for analysis. The

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3 323 researcher examined the data chronologically, in logical order, as noted on the figure 2
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5 324 flowchart of work activities. Regarding the meetings and workshops with industry, it should
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7 325 be noted that discussions (i.e. spoken words) between stakeholders revolved around the
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9 326 functioning of the innovation, how it should/could be used and how it would potentially impact
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11 327 (positively or negatively) project work practices. Whilst acknowledging that such
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13 328 conversations and ‘messy talk’ are intrinsically a part of collaboration using BIM (Dossick and
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15 329 Neff, 2011), the focus of analysis was the ‘organization of practice’ concepts of Schatzki (Table
16
17 330 1) and how and when they manifested. As noted, this manifestation would be through spoken
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19 331 dialogue, shared artefacts and plans of action to be taken forward. Such a microanalysis of
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21 332 processes takes into account the complexities of human life for a practice-oriented study (c.f.
22
23 333 Cicmil and Hodgson, 2006, p.10): the deeper examination of interactions also addressing the
24
25 334 need for fine-grained studies of the work occurring (Blomquist et al. 2010, p.7). As noted in
26
27 335 the following sections, the social practice analysis facilitated clarifications of how ‘sayings’
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29 336 transform into ‘doings’ of innovation delivery and use; the preferences of practitioners leading
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31 337 to a provisional ‘schema for innovation’ for a construction context.
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40 339 [Figure 2]
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45 341 **Innovation Analysis**

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48 342 The BIM Risk Library project commenced in 2019 under the Discovering Safety research
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50 343 programme: a collaboration between the Thomas Ashton Institute (TAI, 2020), the University
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52 344 of Manchester and the Health and Safety Executive (HSE), UK regulator of workplace health
53
54 345 and safety. Aiming to assist design and construction professionals to better manage health and
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56 346 safety via proactive use of digital technologies and mobilisation of information resources via a
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58 347 Prevention Through Design (PtD) approach (Yuan et al. 2019), research work resulted in a
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3 348 novel BIM-based tool developed within a commercial cloud-based platform (the BIM Risk
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6 349 Library). Four different companies, with a total of six separate construction projects partnered
7
8 350 with the research project. Each project agreed to use the innovation, formalizing their
9
10 351 commitment via signed collaborative agreements. The projects had an average duration of four
11
12 352 months, and ranged in type (i.e. residential; industrial; commercial; infrastructure projects). By
13
14 353 way of illustration, a screenshot of the BIM risk library tool is given in figure 3.

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20 355 [Figure 3]

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26 357 Separate work activities of the BIM risk library are now examined in sequence, as shown on
27
28 358 figure 2.

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32 33 360 *Steering Committee Formulation*

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36 361 A Steering Committee was setup for the BIM Risk library composed of research project
37
38 362 stakeholders. A primary source of membership was the BIM 4 Health and Safety Group
39
40 363 (BIM4H&S): a UK industry group focused on digital technologies to improve construction
41
42 364 health and safety. This group was instrumental in work leading to the industry standard PAS
43
44 365 1192-6: 2018 'Specification for collaborative sharing and use of structured health and safety
45
46 366 information using BIM' (BSI, 2018): a working link with this group therefore being important
47
48 367 as the innovation addressed digital technologies to improve construction health and safety.
49
50 368 Frequent communication with the Steering Committee membership ensured that both *general*
51
52 369 *understandings* and *practical understandings* of the innovation were discussed openly from an
53
54 370 early stage. As research team ideas regarding the innovation evolved, these could be bounced
55
56 371 off Steering Committee members; such interactions being an essential social aspect of

1
2
3 372 innovation development. *Rules* around innovation use were also discussed and clarified with
4
5 373 industry figures in a collaborative way at meetings. Amongst the questions asked were: how
6
7 374 would the innovation impact existing project ways of working? What training and instruction
8
9 375 would be provided? And how long would the innovation be mobilised? How could data be
10
11 376 drawn from live projects and anonymised? These practical questions were critical for the
12
13 377 further development of the innovation. The Steering Committee were consulted at regular
14
15 378 intervals through the research project; the link being vital for *understandings* and *rules* of use
16
17 379 to emerge.

380 *Ontology and ERIC matrix*

381 A foundational idea of the BIM Risk Library was formulation of an ontology to map out the
382 elements that make up a risk scenario requiring specific treatments: the ontology concepts
383 being rooted in industry guidance and previous academic work in the field. Details of the
384 ontology and matrix are provided in Collinge et al. (2020b). The ontology embodied rules
385 regarding types of data to be collected and the relations between them. Validation of the
386 ontology and matrix came from the Steering Committee and BIM4 H&S group, which again
387 enabled *general understandings* and *practical understandings* regarding the foundational
388 ontology and its` conceptual underpinning to be reviewed, and confirmed as valid. The
389 research team made notes of such discussions at the time for future reference.

390 *Industry Workshops*

391 The ontology was mobilised in industry workshops to populate nine risk scenarios with relevant
392 treatments. The workshops affirmed the validity of the ontology and the overall approach of
393 the research; both *general* and *practical understandings* of the conceptual ideas being reviewed
394 and discussed by practitioners at the workshops. It should be noted that no contracts or
395 specialised procedures were required to set up the workshops: individuals joined through

1
2
3 396 professional interest and commitment to improving construction health and safety. Resulting
4
5 397 from the workshops, a dataset of 9 risk scenarios and 162 treatments were identified to
6
7 398 eliminate, reduce, inform, or control (ERIC) the risks covering four different stages of the
8
9 399 project lifecycle: preliminary design, detail design, pre-construction, and during construction.
10
11
12 400 The industry workshops maintained and consolidated the relationship with project
13
14 401 practitioners.

17 402 *Prototype Innovation*

19
20 403 The dataset of 9 risk scenarios and 162 mitigations provided the basis for the prototype
21
22 404 innovation: the dataset being saved as a comma-separated values (CSV) file. At this stage of
23
24 405 innovation development, it should be noted that *general understandings, practical*
25
26 406 *understandings* and *rules* regarding the innovation had been discussed several times over with
27
28 407 industry experts. *Rules* regarding innovation use had been captured in notes to be taken forward
29
30 408 into discussions with software developers. Both positive and negative potential reactions to
31
32 409 the innovation by designers and companies (i.e. *teleoaffectivites*) had also been remarked upon
33
34 410 several times over in meetings. The research team recognised the importance of addressing
35
36 411 these in the work going forward.

41 412 *Software development*

43
44 413 Following a review of BIM software providers on the market, one specific software vendor
45
46 414 was selected and a legal contract set-up between research partners and the vendor so the
47
48 415 ontology and dataset could be hosted on a BIM software platform via a specifically designed
49
50 416 interface (figure 3). This important step would allow a sharing of the innovation with industry,
51
52 417 facilitating further population of the library with data by designers working on multiple
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54 418 projects. The contract with the software vendor was vital to this task: an insight here being the
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3 419 need to reserve project funds for software development (if expertise/capability is not within the
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5 420 research team).

6
7
8 421 The software vendor contract formalized the *general/practical understandings* and *rules* of use
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10 422 of the innovation, previously discussed in workshops, meetings, etc. Therefore, the “sayings”
11
12 423 around innovation use were formalized in written form: specific “rules” that were to be codified
13
14 424 into interface functionality of the software. For example, the preference to present project
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16 425 designers with a series of optional treatments for different risk scenarios rather than definitive
17
18 426 solutions was codified into interface use (see figure 3). Both *general* and *practical*
19
20 427 *understandings* and *rules* of use of the innovation were later to be made explicit in a printable
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22 428 User-Guide for designers. *Teleoaffectivities* (emotive reactions to the innovation) could only
23
24 429 partially be addressed during this stage of work as the research team and software developers
25
26 430 attempted to predict possible positive and negative reactions when the innovation would be in
27
28 431 use. Further activities needed to be done to address such issues.

32 33 34 432 *Innovation Piloting*

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36 433 Having developed the prototype, it was necessary to pilot it to validate work completed and
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38 434 begin the process of collecting more risks/treatments. Piloting began in Summer 2020 with 4
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40 435 industry partners and 6 projects. A dedicated support service was setup to assist pilot projects
41
42 436 with any questions they had about using the innovation – this service assisting with
43
44 437 *understandings* and *rules of use* questions. Whilst each pilot was uniquely different, they all
45
46 438 shared a common commitment to identify risks and improve health and safety. It was through
47
48 439 piloting that opinion of the innovation was collected, with positive and negative reactions being
49
50 440 captured via informal feedback and a more formal survey and interviews. Piloting was
51
52 441 therefore very important: changes and amendments to the innovation could be usefully actioned
53
54 442 prior to a much larger rollout to industry. By the end of the piloting phase (June 2021), a CSV
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56 443 file containing 401 treatment prompts for 31 risk scenarios related to 11 different risk categories

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3 444 had been added to the BIM risk library. A number of legal artefacts were associated with the
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5 445 piloting work (figure 2). These are discussed in the following section.
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8 446 *Innovation Evaluation* 9

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11 447 Following piloting and collection of data over a 5 month period, an evaluation process was
12
13 448 initiated. A questionnaire survey and interviews with users provided opinions about the digital
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15 449 innovation. The interviews allowed more detailed opinions of the innovation from industry
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17 450 users of the innovation to be captured. Table 2 gives demographic information regarding the
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19 451 survey participants and interviewees.
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23 452 [Table 2]
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28 454 The survey revealed that 85% of experts agreed or strongly agreed that the innovation could
29
30 455 positively impact design decisions and support selection of appropriate treatments to mitigate
31
32 456 health and safety risks. Although 13 is not a large number of survey respondents, the positive
33
34 457 comments of construction experts validated the innovation. Furthermore, such a sample
35
36 458 number aligns with the guidance of Hollowell and Gambatese (2010), who note the value of
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38 459 small sampling numbers, where a minimum of eight experts is recommended to validate a
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40 460 research proposition. Furthermore, interviewees perceived that adding safety information to a
41
42 461 BIM model, and pinpointing risks added value to their safety management processes. Another
43
44 462 benefit noted was the structured approach to inputting risk data and the opportunity for
45
46 463 collaborative work which the innovation enabled. As part of the evaluation, *understandings*,
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48 464 practicalities of the innovation, *rules* of use and *teleoaffectivities* were all queried through
49
50 465 questionnaire survey and interview questions. For further information regarding the innovation
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52 466 survey, see Osorio-Sandoval et al. 2021).
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59 467 *Publicity*
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3 468 The innovation was presented at several national and international events (e.g. Digital
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5 469 Construction Week 2019; BIM for Water event 2019) and subsequently, won two prizes
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7
8 470 (buildingSMART 2020; Construction Computing Award 2021): these prizes confirming the
9
10 471 value of the innovation to industry. Publicity is a vital aspect for any successful innovation,
11
12 472 providing opportunity to communicate positive opinions and teleoaffectivity emotions about
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14 473 an innovation to a wider audience.

16
17 474 As noted on figure 2, several legal artefacts emerged as innovation work progressed.
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19 475 Examination of the Collaborative agreements and Data Management Workflow provide
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21 476 evidence regarding how an enactment of a distinct “schema” for innovation delivery became
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23 477 tangible in written form and procedural guidelines.

24 25 26 27 478 ***Collaborative Agreements***

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29 479 Collaborative agreements between industry partners, the HSE and the University detailed
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31 480 specific information and instructions concerning use of the innovation and creation of the BIM
32
33 481 Risk Library. These were approved by each party’s legal teams and signed by organisational
34
35 482 senior executives. The agreements covered issues such as data protection and anonymisation
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37 483 of data shared with the library. Provision of free software pilot licences to cover the pilot
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39 484 period and specific terms/conditions regarding long term use of data were also detailed.
40
41 485 Support to be provided to industry partners, including training and instruction to assist users,
42
43 486 and plug-in development to facilitate innovation use with different software packages were also
44
45 487 specified in the agreements. A Data Workflow (figure 4) visualizing the data collection process
46
47 488 for the BIM risk library was included in the agreements. With the agreements we see a shift
48
49 489 from innovation “sayings” to written formalisations of understandings and rules of use, prior
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51 490 to actual “doings” taking place.
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3 491 As noted, the agreements formalise and make explicit the shared thinking around the innovation
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5 492 (i.e. general/practical understandings of it; rules concerning its` use) already established
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7 493 amongst stakeholders; an absence of shared thinking being identified as potentially detrimental
8
9 494 to collaboration if not established (Aarseth et al. 2012). For innovation developers, obtaining
10
11 495 formal agreement to use an innovation is crucially important, so the language used to compose
12
13 496 the collaborative agreement needs to be worded correctly. The collaborative agreements meet
14
15 497 the points noted by Lokuge et al. (2019) as being important regarding organizational readiness
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17 498 for digital innovation: namely, resource readiness, IT readiness, cognitive readiness,
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19 499 partnership readiness, innovation valance, cultural readiness and strategic readiness.
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26 501 Additionally, the collaborative agreements brought order to the innovation process so that all
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28 502 parties know their roles and responsibilities going forward, facilitating the transformation of
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30 503 the digital innovation from a prototype to technology in use. The underlying parameters form
31
32 504 part of an “enacted schema” for innovation delivery (see Discussion), facilitating a collective
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34 505 goal and creating a team ethos and general understanding of objectives (c.f. Uhl-Bien et al.
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36 506 2007).
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41 42 508 ***Data Management Workflow***

43
44 509 Intrinsic to innovation development was the Data Workflow for retrieval, review,
45
46 510 anonymization and uploading of data to the BIM risk library. This workflow (figure 4) was
47
48 511 integrated into the Collaborative agreements and embodied in processual terms the *rules* and
49
50 512 preferences of practitioners regarding innovation use on their projects. For example, the
51
52 513 workflow details how risk scenarios and treatments inputted by pilot projects were to be
53
54 514 retrieved periodically from the cloud by the research team to be anonymized by removal of
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56 515 sensitive or project-specific information. The overall workflow shows how data was to be
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3 516 collected in a non-intrusive way: this being an effective and important provision of practitioners
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5 517 using the innovation. The workflow was a necessary and informative device to re-assure
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7 518 practitioners how the innovation would practically function, and how data drawn from projects
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9 519 would input into the growing BIM risk library. It complimented and clarified information
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11 520 given in the Collaborative agreements: clear communication on how an innovation will
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13 521 function in the project management context being vital.
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19 523 [Figure 4]
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24 525 The workflow also enacting the preferences of industry by defining the operation of the
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26 526 innovation in a project management context: data security; non-intrusive interactions with
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28 527 practitioners; a finite timespan of work activity; an easy to understand plan of action all being
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30 528 clarified. These preferred preferences of innovation users can be understood as being part of
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32 529 the enacted schema for innovation delivery (Figure 6).
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38 531 **Discussion**

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40 532 The review of the BIM Risk library work activities, together with the collaborative agreements
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42 533 and data workflow evidences the presence of Schatzki's 'organisation of practice' concepts
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44 534 (general/practical understandings; rules; teleoaffectivities – emotive behaviours) that together
45
46 535 characterise a distinct practice. The evidence indicates how "sayings" regarding innovation
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48 536 evolve into "doings" via formalised agreements and contracts between parties. Such a
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50 537 transformation is necessary for companies operating in competitive and data sensitive
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52 538 environments. Therefore, whilst the digital innovation journey has been recognised as an
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54 539 "ongoing social accomplishment" pivoting around "negotiated interactions between the main
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56 540 parties" (Bresnen, 2009, p.931), a social practice analysis brings greater clarity to the processes
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3 541 occurring in terms of human behavioural aspects underpinning an innovation. The findings
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5 542 enable further reflections on the existing literature in terms of theoretical and practical
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8 543 contributions.

9
10 544 ***Theoretical Contribution***

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12 545 The social practice analysis of interactions and artefacts associated with the BIM risk library
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14 546 innovation align with the framework of innovation diffusion of Steiber and Alänge (2015): the
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16 547 five step process (desirability; feasibility; first trial; implementing; sustaining) being evidenced
17
18 548 on the BIM risk library in terms of the work activities followed. The social practice analysis
19
20 549 adds a layer of detail to this framework in terms of how understandings emerge, rules are
21
22 550 established, formal agreements are made and emotive behaviours manifest. With regards to
23
24 551 Rogers (1995) six innovation-characteristics that matter for its` diffusion in a social system (i.e.
25
26 552 relative advantage for the adopter; compatibility with existing system; complexity/difficulty to
27
28 553 learn; testability; potential re-inventions; observed effects), the social practice analysis
29
30 554 provided evidence of how each of these are linked to shared understandings, rules and emotive
31
32 555 behaviours. A key insight is the importance of relational conditions underpinning innovation
33
34 556 use and good working relationships between partners. That mutual dependencies can result in
35
36 557 friction, satisfaction or other emotive behaviours (teleoaffectivities) is a reality when using an
37
38 558 innovation. The various work activities occurring prior to innovation launch established
39
40 559 positive relational conditions (formalised via the collaborative agreements). The empirical
41
42 560 evidence suggests that digital transformation is not the simple application of a new technology
43
44 561 into a project context, but an all-round transformation of project processes that connect with
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46 562 management, business and organization methods. The paper illustrated how activities leading
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48 563 to innovation development together with the collaborative agreements and data workflow
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50 564 provided a solid foundation for effective innovation delivery.
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3 566 The interplay between the dynamic process of innovation use and more routinized processes
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5 567 of project management work (Bygballe et al., 2016) has been noted as an important one. The
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7 568 paper illustrates how this dynamic can be played out: the BIM risk library Data Workflow
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9 569 (figure 4) linking to issues of importance for practitioners under pressure to deliver work to
10
11 570 time and budget whilst minimising disruption to project processes. Innovation developers and
12
13 571 practitioners need to enter into trustful relationships for innovations to be given a chance for
14
15 572 success; legal artefacts like collaborative agreements enable innovations to be tested,
16
17 573 developed and deployed in transparent ways. The insights from the BIM risk library enable
18
19 574 the practice of innovation delivery to be clarified (figure 5) in terms of how “sayings” transform
20
21 575 into “doings”. As a result, the construction context for innovation may be understood as a
22
23 576 distinct “field of practices” (Schatzki, 1996, 2001) with its` own distinctive schema of
24
25 577 “preferences and prescriptions” (Knorr Cetina, 2001) of developers and practitioners, as
26
27 578 highlighted in figure 6. Reference to such a schema is useful for both technology developers
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29 579 and innovation developers addressing practicality issues.
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581 [Figure 5]

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583 ***Practical Contribution***

584 Digital innovations demand changes to working practices (c.f. Cicmil and Marshall, 2005),
585 with new practices emerging as people coordinate in new ways (Cicmil et al. 2006; Sage et al.
586 2012). A social practice analysis clarifies how this happens in actuality (in terms of
587 understandings, rules and emotive behaviours). Such a study extends understanding of the
588 decision-making processes managers use in the adoption of new technologies and strategies
589 used to deal with uncertainty (Mitropoulos and Tatum, 1999). On the BIM Risk library,
590 industry partners signed collaborative agreements following extended periods of discussion

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3 591 with research partners, establishing their understandings and agreed parameters of innovation
4
5 592 use. Deriving from the BIM risk library, figure 5 illustrates how such discussions formalise
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7 593 into agreements prior to innovation use. As indicated in figure 5, the practice of innovation
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9 594 delivery and its' associated sayings, doings and formalisations may be visualised to have a
10
11 595 relationship within which the preferences of stakeholders are emergent, formalised and enacted
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14 596 upon.

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19 598 If we follow Knorr Certina's (2001) definition of practices as "recurrent processes governed
20
21 599 by specifiable schemata of preferences and prescriptions", we can begin to identify an
22
23 600 underlying schema for innovation delivery in construction. Analysis of the BIM Risk Library
24
25 601 assists in such a process and adds a level of social understanding lacking in models such as the
26
27 602 technology-acceptance model (TAM) that fail to recognise user acceptance over time (Liu et
28
29 603 al. 2018). Figure 6 draws together insights from the empirical evidence to present an enacted
30
31 604 schema for innovation delivery in construction. It is contended the schema should be reflected
32
33 605 and enacted upon in order to make an innovation successful in a construction context.
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35 606 Additionally, the schema addresses the three tenets of Havenid et al. (2019) in a recent
36
37 607 collection of works on innovation in construction; these tenets being to shed light on the
38
39 608 organisational processes within contexts of innovation in construction; to apply novel
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41 609 theoretical perspectives to empirical phenomena, and to recognise the temporal and spatial
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43 610 distribution of innovation as processual activities.

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51 612 [Figure 6]

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53 613 The figure 6 schema notes the prescriptions and preferences of developers and practitioners for
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55 614 effective innovation delivery. Developer prescriptions include clear definitions of the purpose
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57 615 and benefits of an innovation; clarity over roles/responsibilities of parties; clarity on how the
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3 616 innovation will work/function. Preferences note aspects which would support successful
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5 617 innovation deployment, including the social practice concepts of Schatzki and the need to
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7 618 minimize disruptions to project work processes. A developer preference would be the
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9 619 importance of reducing negative emotive reactions whilst promoting positive reactions if
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11 620 possible. The collaborative agreements, data workflow (embodying general/practical
12
13 621 understandings, rules and purpose of the innovation), and user guide emerged as the project
14
15 622 evolved at a moment in time that was required for progression of the innovation. These
16
17 623 artefacts of innovation embody the prescriptions and preferences of developers and
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19 624 practitioners. These are shown in figure 6 as emerging from the processes. The various
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21 625 meetings, communications and work interactions preceding their creation were important in
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23 626 preparing industry partners for the innovation itself and laying the groundwork for its` uptake.
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30 628 **Conclusions**

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33 629 The paper advances understanding of successful digital innovation delivery in construction
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35 630 project management through a social practice analysis of various activities and outputs
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37 631 associated with one innovative technology (the BIM risk library): i.e. discussions; legal
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39 632 agreements; innovation workflow; software artefact; user guide). A limitation of the paper is
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41 633 that the insights are drawn from one single study of innovation delivery. Whilst single case
42
43 634 studies can be criticized from a data limitation point-of-view, it should be noted that 4 different
44
45 635 companies used the innovation on 6 separate projects over several months. Therefore, the data
46
47 636 upon which the study is based is not insubstantial. Additionally, as the innovation has garnered
48
49 637 attention and won awards, it is contended that the insights of the paper are useful and
50
51 638 informative for industry innovators and the academic community. Additionally, the paper
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53 639 provided tangible insights into how an innovation can emerge from context-specific
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55 640 interactions (e.g. industry workshops; software vendor negotiations; piloting work) where
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3 641 general and practical understandings of an innovation, rules regarding its' use and
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5 642 teleoaffectivities (emotive behaviours) are part of the discourse. Employment of Schatzki's
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7 643 'organisation of practice' concepts to examine the interactions occurring and the resultant
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9 644 artefacts shared between collaborators highlight the importance of understandings, rules and
10
11 645 emotive behaviours in the innovation journey. Whilst the evolutionary nature of innovation
12
13 646 development was described, a distinct 'field of practice' for innovation delivery came into
14
15 647 focus, with a 'schema of generalisable preferences' emerging from the social practice analysis
16
17 648 (figure 6). Artefacts such as legal agreements, software product and innovation workflow
18
19 649 evidenced how the innovation discourse shifts from verbal "sayings" to formalised agreements
20
21 650 and contracts that embody the preferences and prescriptions of practitioners: the practical
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23 651 realities of innovation use being translated into a tangible schema prior to their "doing" in
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25 652 construction project contexts. The findings complement existing frameworks for
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27 653 understanding innovation delivery in project management contexts and provide an extension
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29 654 to the body of knowledge on factors contributing to innovation delivery in construction.
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38 656 **Data Availability Statement**

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40 657 Some or all data, models, or code generated or used during the study are available in a
41
42 658 repository or online in accordance with funder data retention policies
43
44 659 (<https://www.discoveringsafety.com/>).
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57 665 improvement of the paper.
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Disclaimer

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8 668 The author reports there are no competing interests to declare.
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Ethics Statement

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14 671 The research obtained ethics approval from the University of Manchester Ethics Committee.
15
16 672 Subsequently, informed consent was received from the research subjects.
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Figure captions

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Fig 1. Framework for diffusion of innovations

Fig.2. BIM risk library screenshot

Fig.3. Flowchart of work activities

Fig.4. Data management workflow

Fig.5. Practice of innovation delivery

Fig.6. Schema for innovation delivery

Practical Understandings	Knowing how to execute desired actions through basic doings and sayings.
Rules	Formulated directives, admonishments and edicts; rules can be defined as “methodically applied generalizable procedures of action”.
Teleoaffectivities	Acceptable and enjoined emotions, moods and actions associated with certain practices.
General Understandings	Understandings or senses of general matters pertinent to goings-on in practices.

Table 1: ‘Organization of practice’ concepts (Schatzki, 1996)

Expert ID	Area of work	Experience in the construction industry (Years)
EXP-01	Design	45
EXP-02	Other (specify) <i>All stages</i>	41
EXP-03	Other (specify) <i>All stages</i>	40
EXP-04	Design	5
EXP-05	Other (specify) <i>All stages</i>	44
EXP-06	Strategic planning	15
EXP-07	Construction	33
EXP-08	Design	40
EXP-09	Construction	33
EXP-10	Construction	49
EXP-11	Design	33
EXP-12	Other (specify) <i>CDM Principal Designer</i>	35
EXP-13	Design	28

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Table 2: demographic information of survey/interviewee experts

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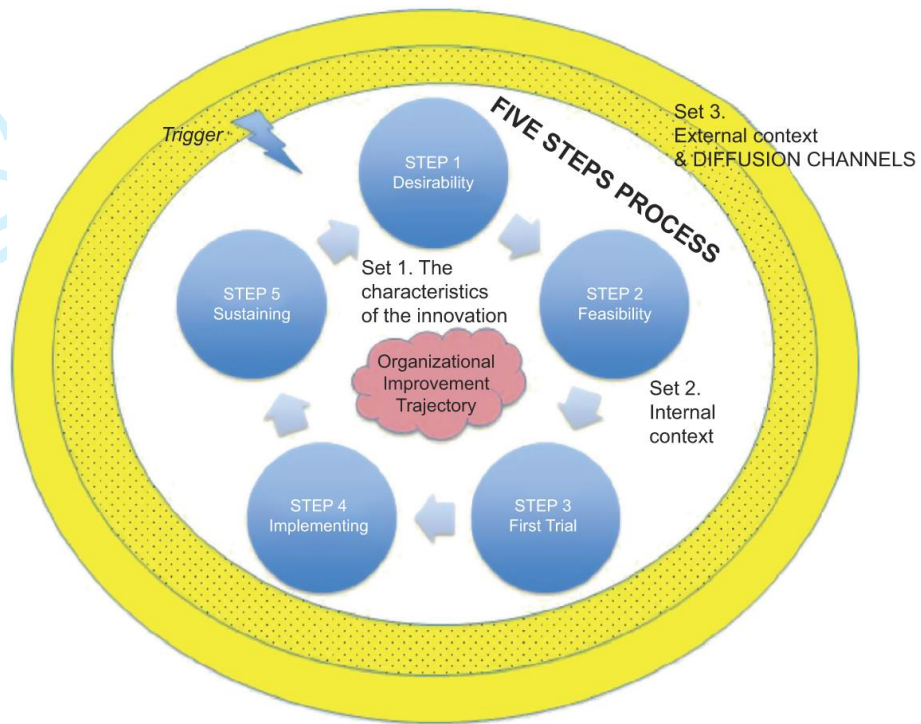


Figure 1: Framework for diffusion of innovations (Steiber and Alänge, 2015)

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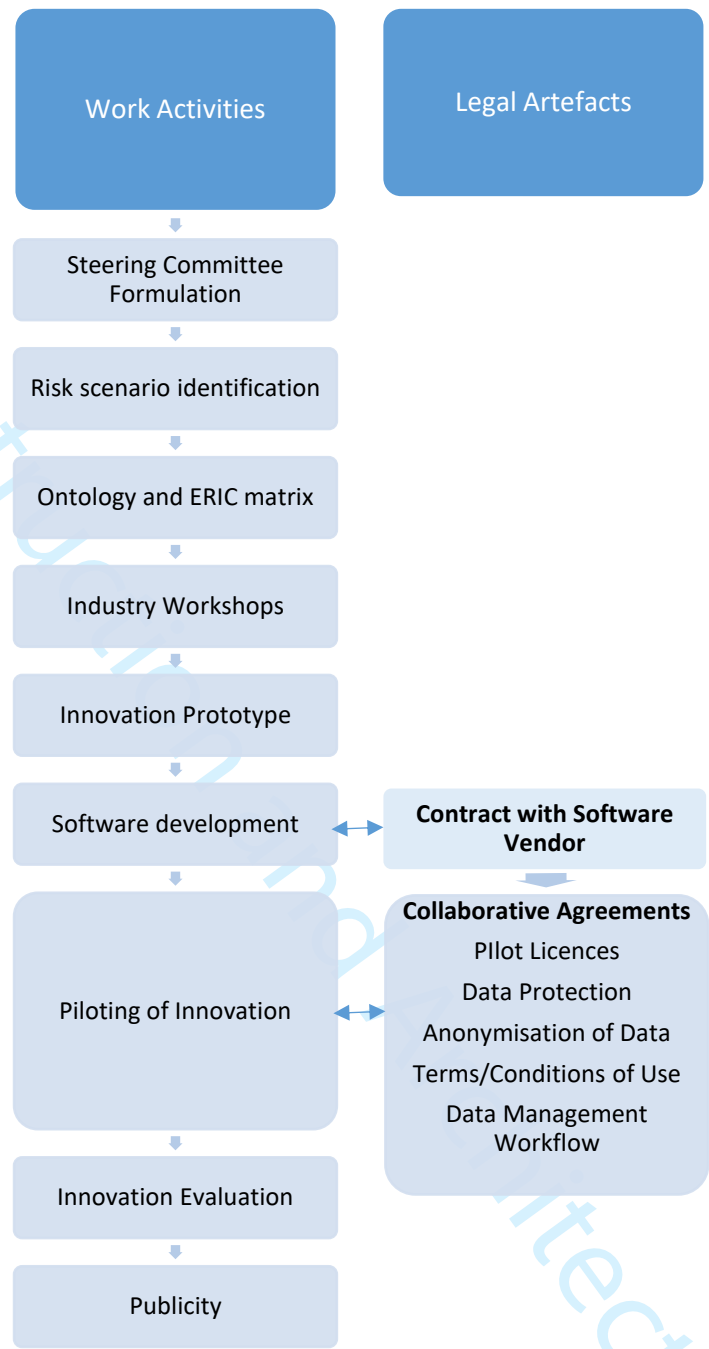


Figure 2: Flowchart of work activities

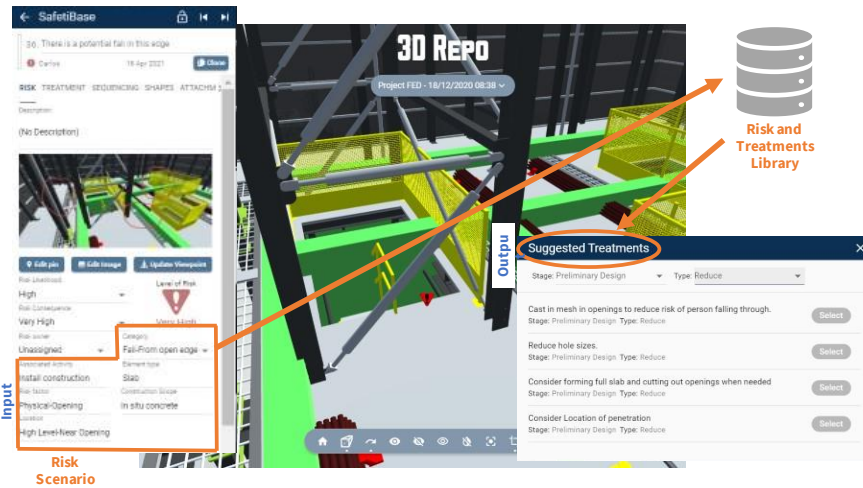


Figure 3: BIM risk library screenshot (from Project Safety Journal, Winter 2022, p.14)

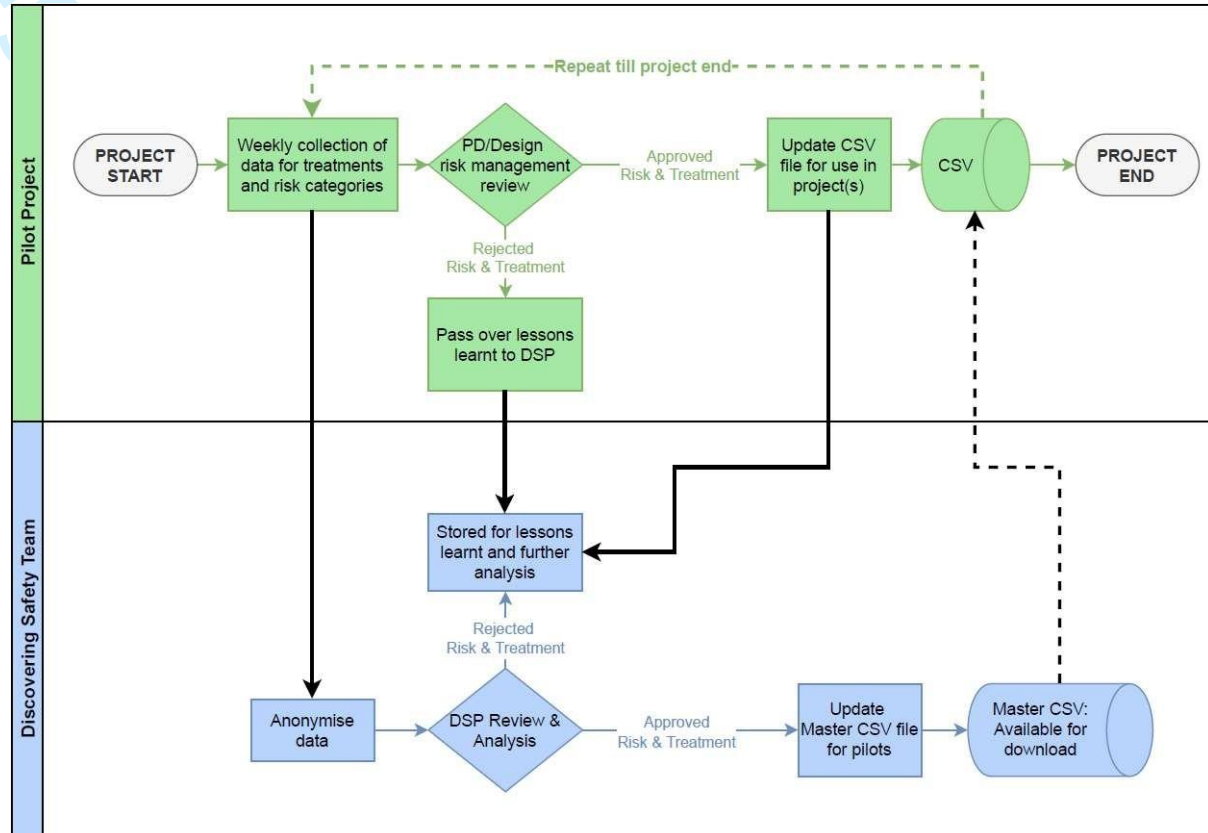
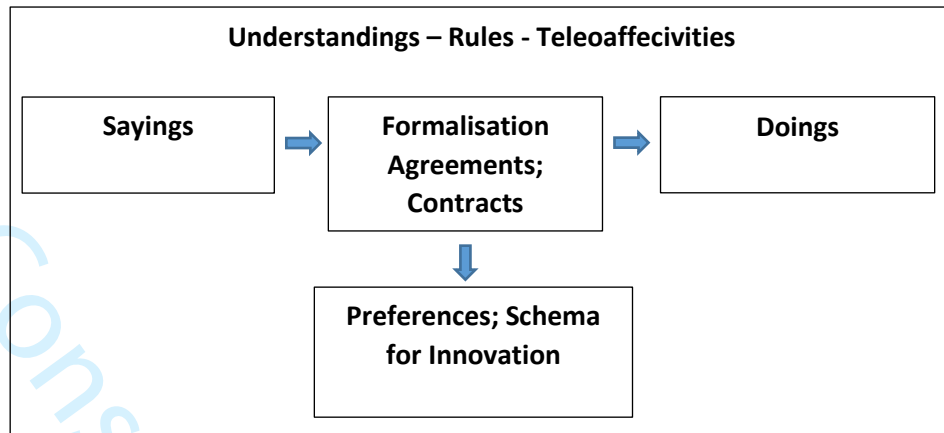


Figure 4: Data management workflow (from Osorio-Sandoval et al. 2021, p.9)



18 Figure 5: Practice of innovation delivery - sayings, formalisation, doings
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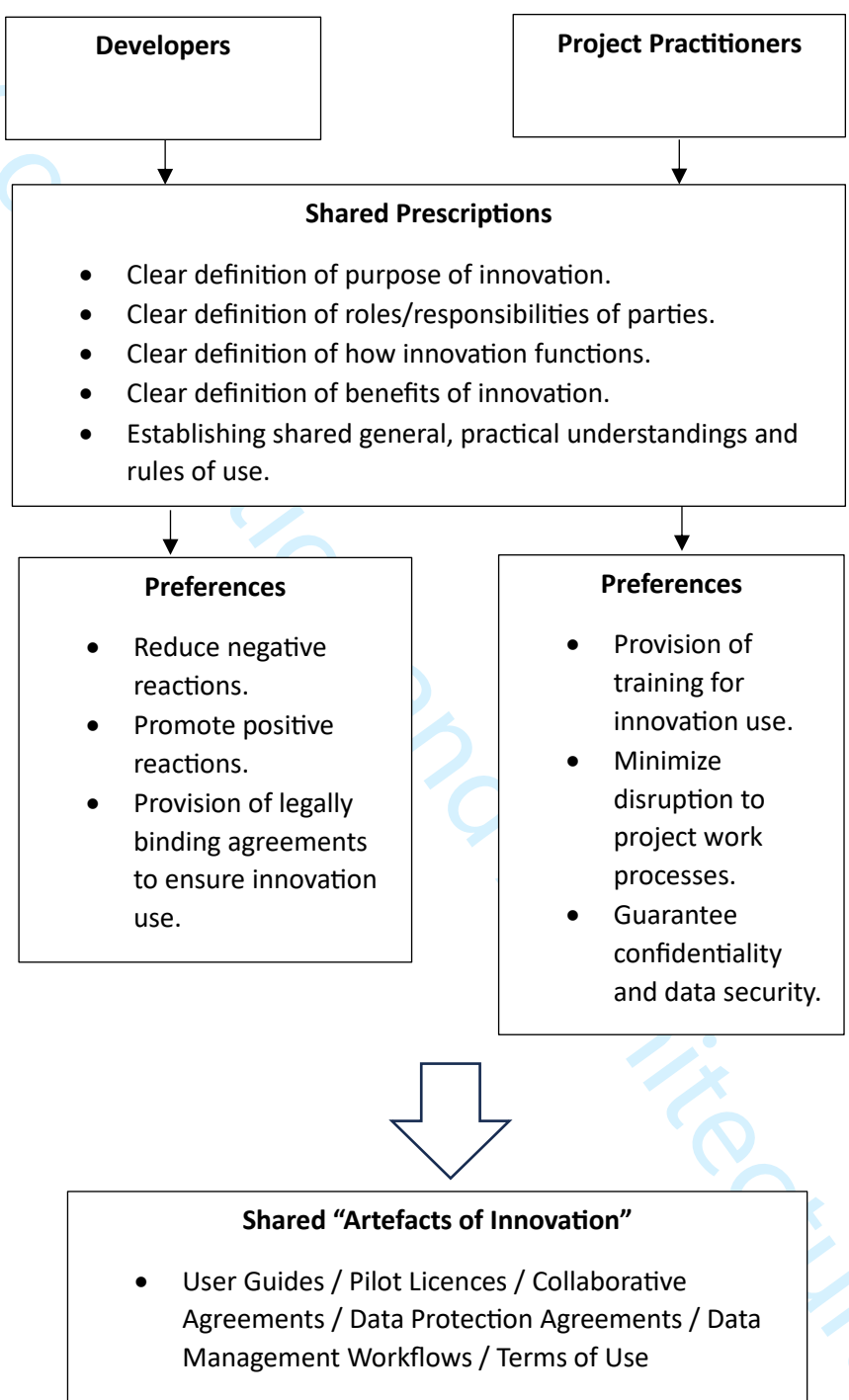


Figure 6: Schema for innovation delivery

Reviewer Comments & Responses

*The author/s thank the Reviewers for all their comments and detail below the responses.
Reference to manuscript lines of text refers to the Tracked Changes version of the paper.*

Reviewer 1 Comment	Response
1) Given the title is "digital innovation delivery", it would be interesting to see the analysis of innovative technologies used in the project production and construction such as robotics and other digital tools.	The paper analysis and contribution stems from one digital technology: the BIM Risk Library. Whilst further studies on other digital technologies is merited and valuable (e.g. robotics), it is beyond the scope of the paper.
2) Majority of the references seem outdated. This impedes some statements from generating a firm conclusion and might leave out some state-of-the-art studies to this study.	A further literature review identified several more recent papers regarding innovation in construction. These have been integrated into the literature review section (lines 135 - 142). No specific more recent papers were identified that that adopted a social practice theoretical and conceptual analysis of innovation as this paper does.

Reviewer 2 Comment	Response
Figures 4 and 5 should be adopted on the context of this research. The main innovation made (BIM Risk Library) and its elements should be linked into these Figures.	The accompanying text in the paper for Figures 4 and 5 and the Figure labels have been amended to clarify the link between the BIM Risk Library and the figures themselves.
Limitations should go to the Conclusion section.	This comment has been addressed. The Limitations text being moved to lines 665 - 671.
It is recommended to not incorporate citations and references in the Conclusion section.	This comment has been addressed.
The methodology should be enhanced. Its methodological standpoint and foundation should be theorized first and then, the research process and steps can be built upon.	The methodology section has been revised and enhanced. The theorization and practical aspects of the methodology are now clearly demarcated.
The presentation and visualization of the results should be significantly improved.	Thankyou for the comment. The original schema of innovation delivery (Table 3) has now been replaced by a new figure 6 and further text in the paper to enhance the presentation and visualization of the results.

Reviewer 3 Comment	Response
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<p>In its present form, the abstract appears to lack specificity and clarity regarding the study's purpose, adopted methodology, results and key findings, and the expression of the originality of the work. The abstract should provide a concise yet comprehensive overview, clearly outlining the aim of the study, describing the methodological approach used, highlighting key findings, and emphasising the original contributions of this research.</p>	<p>The Abstract has been reviewed and revised in light of the comments.</p>
<p>The originality of this study should be more specifically presented in the abstract and introduction sections.</p>	<p>The text has been edited and new text added to these sections (Abstract & lines 109 – 113).</p>
<p>The literature lacks critical reviews of digital innovation delivery and the BIM Risk Library. The current section only discusses the practice of innovation delivery and social practice theory. But the link between digital innovation delivery, i.e., the BIM risk library, is not sufficiently presented.</p>	<p>The work processes of the BIM Risk Library and the analysis of those processes using social practice theory is the main focus of the paper and is not presented in the Literature Review section. The Literature Review sections have been reviewed and improved in places (see comment above).</p> <p>A further literature review was done in light of this comment, but no further relevant papers regarding application of social practice theory were identified to integrate into the text. If the reviewer believes there is a specific omission regarding specific reference/s, the author/s would be pleased to integrate them into the text as necessary.</p>
<p>Lines 137: “analysis of exemplar “successful” innovations can provide the empirical data” discussing some examples here would be beneficial to prove your argument.</p>	<p>The argument is from Söderlund, and is not the author/s own.</p>
<p>In the literature review section, the paper initiates a discussion on practice theory starting from line 147 onwards, wherein the authors delve into examples illustrating epistemological and ontological uncertainties. However, the current exposition, particularly in lines 150 and 155, lacks precision, leaving questions about the link between the examples and their contribution in the broader argument. To enhance clarity and conciseness, it is recommended to refine this part, ensuring they are both comprehensive and directly relevant to the overarching points regarding epistemological and ontological uncertainties.</p>	<p>The criticism is that the section of text lacks precision in noting the deficiencies in practice theory studies. These deficiencies are as reported by published work in the field. For example, O’Keeffe et al. note it is the “doing” and “performance” of practice that should be the basis of practice theory analysis, whilst Marshall notes that practice theorists often fail to provide empirically sound demonstrations of theoretical propositions in action.</p> <p>However, further text has been added to the section to clarify the argument being made (lines 188 – 190).</p>

<p>The overall presentation of the methodology is okay. However, it needs to be more organised and concise yet comprehensive.</p>	<p>The methodology section has been reviewed and revised in light of the comment.</p>
<p>It is suggested to include aspects that were raised via questionnaire survey and interviews in detail. Does the survey include only 13 participants? If yes, what is the justification for generalising the finding in Line 439 (the survey revealed that 85% of experts agreed or strongly agreed...).</p>	<p>Views of the innovation from the questionnaire survey and interviews have been integrated into the paper (lines 474; 480- 484). An additional reference to the survey has been added (line 485 486) for readers wishing to follow up this issue.</p> <p>Regarding the survey, and the 13 valid responses, further text has been added to the paper to support the validity of presenting views from the 13 responses (lines 476 - 480). A supporting reference for the use of such a sampling number is also provided (line 478).</p>
<p>Why were two different data collection methods employed (with the same set of participants)?</p> <p>The data collection procedure should be more comprehensive.</p>	<p>The data collection procedure was comprehensive in that all pilot projects using the innovation together with many expert practitioners were questioned and surveyed for their opinion.</p> <p>Further text has been added (lines 469; 476 – 480; 485 -486) to explain why a survey instrument and interviews were used.</p>
<p>The discussion should not dominate the new literature; however, the key finding should be supported with relevant evidence. In some cases, the discussion could be further enhanced by providing some practical examples that explain the results of this study.</p>	<p>The discussion has been revised in order to improve communication of the key findings of the paper. In addition to changes in the text, a new figure 6 has been added to the Discussion to achieve this.</p>
<p>Please check for typos and minor syntax errors.</p>	<p>The paper has been checked and corrected where necessary.</p>

1 Advancing social practice understandings of digital innovation delivery in construction
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3 **Abstract**

4 **Purpose**

5 The ~~paper purpose is to applies social practice theory to~~ clarify the process of innovation design
6 and delivery from design and delivery in construction project management contexts through
7 ~~examination of~~ one successful digital innovation: the BIM risk library. The paper clarifies the
8 practices surrounding construction innovation and provides a schema useful for practitioners
9 and technology designers builds upon scholarship in the field, contributing to the body of
10 knowledge by extending existing frameworks of innovation diffusion through a social practice
11 analysis.

13 **Design/methodology/approach**

14 ~~The paper applies Information is drawn from a research project that delivered a new digital~~
15 ~~innovation for industry to improve construction health and safety. Application of Schatzki's~~
16 'organisation of practice' concepts to the construction project innovation to clarify how the
17 ~~process provides insights into the practice of innovation delivery for construction project~~
18 management revolves around understandings, rules and teleoaffectivities (emotive behaviours).
19 Sources for the study include notes from meetings, workshops with experts and the shared
20 artefacts of innovation.

22 **Findings**

23 ~~Findings include~~ The practice of innovation design and delivery are clarified through a social
24 practice analysis: a distinct "field of practice" and for innovation delivery together with a

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3 25 “schema” of generalizable prescriptions and preferences ~~for innovation delivery to be followed~~
4 ~~by innovators being presented.~~
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10 28 **Originality**

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12 29 The social practice analysis of ~~one a successful~~ construction ~~project~~-innovation is an original
13 contribution to the body of knowledge. ~~The paper addings~~ a level of detail regarding
14 innovation design and delivery often missing from ~~previous~~ reported research.
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23 33 **Practical implications**

24 34 The paper informs the practice ~~and process~~ of innovation design and delivery; ~~for technology~~
25 ~~developers and researchers in the field.~~ ~~T~~the insights clarify ~~y~~ how collective understandings
26 ~~of an innovation~~ and rules of use evolve over time, becoming formalized ~~into~~ contracts,
27 agreements and workplans. ~~Practically,~~ ~~The~~ processes whereby innovation ‘sayings’ evolve
28 into innovation ‘doings’ are clarified; a schema ~~for innovation delivery detailing ing~~
29 prescriptions and preferences of practitioners and ~~innovation~~ developers ~~being presented being~~
30 ~~presented.~~
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42 42 **Keywords:** innovation studies; BIM; building information modelling; digitalisation; projects-
43 as-practice; social practices; health and safety; data engineering.
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61 Introduction

62 Managing an innovation is as important as the innovation development process itself (Bamel
63 et al. 2023); construction project management innovations being interventions into existing
64 complex working practices (Liu et al. 2018). As such, aligning an innovation to those practices
65 to minimise disruption and continue business-as-usual processes is important. Additionally,
66 the process of innovation adoption whereby an innovation becomes part of everyday project-
67 based working practice remains unclear: innovation adoption being a complex business, with
68 little to guide practitioners through the messy and contingent process of adoption and diffusion
69 (Harty, 2005). Therefore, understanding how innovations are delivered is as important for
70 improving innovation practice itself (Havenid et al. 2019). Whilst Winch (1998) notes that
71 more case studies of trajectories of innovation are required in order to identify who generates
72 new ideas and how they are managed into “good currency”, the process of innovation design,
73 prototyping, testing and deployment requires a theoretical and conceptual unpacking using
74 empirical evidence. This paper makes a contribution by examining how one successful digital

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3 75 innovation was developed and deployed with several project-based organizations to become
4
5 76 part of their everyday working practices. The innovation (the BIM Risk Library) was recipient
6
7 77 of several industry awards (buildingSMART, 2020; Construction Computing Award, 2021)
8
9
10 78 and therefore provides valid data regarding a “successful innovation”. Amongst the key
11
12 79 questions posed by the paper are: what contributes to successful innovation deployment in
13
14
15 80 ~~a~~construction project management ~~context~~? What are the drivers and inhibitors of successful
16
17 81 innovation delivery? How can the innovation delivery process be conceptualised and ~~better~~
18
19 82 understood?
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21
22 83

23
24 84 The paper adopts a projects-as-practice (Blomquist et al. 2010) approach and uses social
25
26 85 practice theory (Schatzki, 2001) to review the process of innovation delivery. The case for
27
28 86 adopting a projects-as-practice approach for understanding what occurs on projects has been
29
30 87 made for some time (c.f. Koch et al. 2019; Blomquist et al., 2010; Clegg et al. 2018). In
31
32 88 outlining a projects-as-practice approach to conducting research in project management,
33
34 89 Blomquist et al. (2010) note that project management is an immature field of research, where
35
36 90 many of the normative and traditional contributions are insubstantial when it comes to
37
38 91 understanding what is really occurring in projects (see Winter et al. 2006). Clegg et al. (2018)
39
40 92 argue that practice-based research provides a methodological lens to explore the reality of
41
42 93 project management work; the authors noting that practice-based perspectives are under-
43
44 94 represented in project portfolio management (PPM) research, whilst presenting an agenda for
45
46 95 further practice-based research, including its discursivity, representation, dynamic capabilities,
47
48 96 leadership and materiality. This paper follows this tradition by employing a “social practice”
49
50 97 theoretical perspective to ~~previous~~—established frameworks for innovation diffusion; the
51
52 98 framework of Steiber and Alänge (2015) ~~being providing~~—a foundation upon which a social
53
54 99 practice analysis of processes and interactions may be overlaid.
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1
2
3 100 The paper adopts a granular analysis of the ~~discussions and~~ interactions between ~~the~~ innovation
4
5 101 stakeholders to identify the concepts characterizing a ‘practice of innovation delivery’ that
6
7 102 pivot around rules, understandings and teleoaffectivities (emotive behaviours). The analysis
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9 103 of the work around one successful digital innovation (the BIM Risk Library) –leads to
10
11 104 identification of specifiable enacted schemas (i.e. practitioner preferences and generalizable
12
13 105 procedures) to be addressed by innovation developers. As a result, ~~it is argued that~~ the practice
14
15 106 of innovation delivery in construction contexts is noted to be is distinctive and governed by
16
17 107 specifiable preferences and prescriptions (Knorr Cetina, 2001): understanding construction
18
19 108 working practices and aligning an innovation to those practices being critical for successful
20
21 109 innovation ~~development~~ design and deployment. The originality of the work arises from the
22
23 110 analysis of each step of the innovation design and delivery process and its’ associated artefacts
24
25 111 using Schatzki’s practice theory concepts. The contributions which result, around sayings,
26
27 112 formalisations, doings and a schema for innovation delivery add to the body of knowledge
28
29 113 concerning construction project innovation.

30
31 114 The paper is organised as follows. A literature review scopes out understandings of the practice
32
33 115 of innovation delivery in construction, identifying gaps in knowledge and issues requiring
34
35 116 clarifications. The projects-as-practice literature and social practice theory of Theodore
36
37 117 Schatzki are then presented to provide theoretical orientation and foundation ~~for the study~~. A
38
39 118 methodology section describing the research approach adopted is followed by presentation of
40
41 119 the innovation: the BIM risk library: a collaboration between ~~the~~ University of Manchester
42
43 120 (UK), the UK regulator for workplace health and safety ~~in the UK~~ (the Health and Safety
44
45 121 Executive – HSE), several construction companies and a building information modelling
46
47 122 (BIM) software provider. The A high-level review of ~~work concerning~~ innovation
48
49 123 development work is complimented by deeper analysis of the collaborative agreements
50
51 124 between partner organizations and ~~the~~ data management workflow employed for innovation

1
2
3 125 ~~data harvesting and development. that emerged following discussions between research~~
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5
6 126 ~~partner organisations.~~ Collectively, this evidence distils the ‘field of practice’ (Schatzki, 1996)
7
8 127 of innovation delivery in construction with an “enacted schema” for innovation delivery
9
10 128 coming into focus from the analysis. A following discussion notes how the social practice
11
12 129 findings align and enhance build upon the framework of innovation diffusion of Steiber and
13
14 130 Alänge (2015): innovation evolution being understood in social practice terms, with a schema”
15
16
17 131 for innovation delivery and relations between “sayings”, “formalisations” and “doings” being
18
19 132 presented. A closing conclusion draws the insights of the paper together.
20
21
22 133

134 **Understanding the Practice of Innovation Delivery**

27 135 Recent published work regarding innovation in the construction industry has addressed a
28
29 136 variety of subjects, including the effect of supply chain innovation on competitive advantage
30
31 137 (Afraz et al. 2021), open innovation and the enhancement of productivity (Greco et al. 2021),
32
33 138 innovation ecosystems and collaboration in infrastructure projects (Vosman et al. 2023) and
34
35 139 boundary-spanning for managing digital innovation in the AEC sector (Azzouz and
36
37 140 Papadonikolaki, 2020). Whilst these contributions have added to the body of knowledge
38
39 141 concerning innovations in construction, there remains a need to understand the practice of
40
41 142 innovation delivery. In this respect, whilst ~~Whilst~~ diffusion of innovations across firms has
42
43 143 been recognised as a non-linear process (Shibeika and Harty, 2015), ~~academic~~ research has
44
45 144 also examined how companies organise for digitalization (Morgan, 2019). However,
46
47 145 understandings of the practice of innovation delivery are opaque and ambiguous: understanding
48
49 146 the trajectory of a digital innovation (Winch, 1998), and how an innovation transforms from
50
51 147 research idea to a fully-fledged application being much less understood. It has been noted that
52
53 148 the relationship between system developers and potential industry users can be contentious
54
55 149 (Liu et al. 2018), with challenges towards industry uptake of innovations being considerable
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1
2
3 150 (Oesterreich and Teuteberg, 2016). Whilst technical, practical and social barriers to innovation
4
5
6 151 uptake are commonly evident (Collinge et al. 2020a), Blindenbach and Van Den Ende (2010)
7
8 152 note that project-based firms have more difficulty innovating ~~their own~~ products, services and
9
10 153 operations as compared to when they innovate for their clients. As a result, suitable
11
12 154 engagement strategies and appropriate working relationships with technology developers need
13
14 155 to be established. Blindenbach and Van Den Ende (2010) also note that the effects of specific
15
16 156 management practices on project performance are different, particularly the effects of planning,
17
18 157 multidisciplinary teams and heavyweight project leaders. The authors note that differences in
19
20 158 firm characteristics provide an explanation for the findings; an implication for the innovation
21
22 159 management literature being that “best” practices for innovation management are firm
23
24 160 dependent. Söderlund (2004) points out that process and real-time case studies and project
25
26 161 organization issues are of particular interest, and therefore analysis of exemplar “successful”
27
28 162 innovations can provide the empirical data needed for such studies. ~~:-~~
29
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31
32
33 163 Cicmil (2006, p. 36) asserts that project theory would be served by a qualitative approach with
34
35 164 a critical interpretive lens that might ‘generate alternative understandings of what goes on in
36
37 165 project practice and how practitioners participate in and manage complex organizational
38
39 166 arrangements.’ Consequently, examination of what people do ~~in within the context of~~ project
40
41 167 ~~contexts~~ is a valid analytical approach rather than a confirmation of best practice models for
42
43 168 project management (cf. Geertz, 1973). This aligns with Blomquist et al. (2010), who argue
44
45 169 for a practice perspective (Schatzki, Knorr Cetina, & von Savigny, 2001) that begins with
46
47 170 individual actions and asks what overall models and concepts result from those actions.
48
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51
52 171 Practice theory has been used to study interactions in construction project management
53
54 172 contexts previously, for example to understand digital integration of built-environment
55
56 173 practices (Çıdık et al. 2017) and collaboration in construction (Connaughton and Collinge,
57
58 174 2021), but epistemological and ontological uncertainty remains, ~~particularly regarding the~~

1
2
3 175 delivery of innovations in construction project management. For example, whilst Bresnen
4
5
6 176 (2009) argues that a ‘practice’ perspective allows us to focus on what happens in actuality:
7
8 177 understanding practices being potentially more informative than industry-wide models of ideal
9
10 178 processes, Marshall (2014, p.110) notes that practice theorists often fail to provide empirically
11
12 179 sound demonstrations of theoretical propositions in action, thus limiting the usefulness of ideas.
13
14
15 180 For example, the practice theory objective to clarify the emergent and ongoing constitution of
16
17 181 social orders and change through situated practices has not been substantially engaged with.
18
19 182 Similarly, whilst Blomquist et al. (2010) propose a ‘project-as-practice’ approach for
20
21 183 understanding the complexities of working practices occurring in projects, noting the specific
22
23 184 challenges for the researcher, O’Keeffe et al. (2015) comment that it is the ‘doing’ and
24
25 185 ‘performance’ that should be the basis of analysis in practice theories when stating,
26
27 186 ‘Practice theory refocuses attention on the social nature of organized activities and how these
28
29 187 relations are mediated by the materialities within which they become enmeshed.’ (p. 416). This
30
31 188 paper directly addresses the comments of Marshall (2014) and O’Keeffe et al. (2015) above by
32
33 189 providing an empirical demonstration of practice theory concepts in action, and by highlighting
34
35 190 the “doing” and “performance” of innovation practice in a construction context.
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43 192 Whilst the abovese reflections highlight the importance of empirical evidence for informing
44
45 193 theoretical understanding of practices, in terms of models of innovation, important work has
46
47 194 already been conducted in the field. Rogers (1995) notes six innovation-characteristics that
48
49 195 matter for its diffusion in a social system; these being: its relative advantage for the adopter, its
50
51 196 compatibility with the pre-existing system, its complexity or difficulty to learn, its testability,
52
53 197 its potential for re-inventions, and its observed effects. Building on the work of Rogers, Steiber
54
55 198 and Alänge (2015) present an analytical framework for diffusion of innovations (figure 1). The
56
57 199 framework includes five steps that a firm goes through when searching for, adopting, and
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200 implementing, either a technical or organizational innovation: the five steps being desirability,
201 feasibility, first trial, implementing, and sustaining. These five steps are in turn dependent on
202 a firm's organizational improvement trajectory, which is cumulative and path-dependent due
203 to increased return on investment on existing innovations, as well as on internal inertia among
204 board members, top managers and employees. The five steps are all subject to three sets of
205 influencing factors: characteristics of the innovation, the internal context, and external context
206 (that include diffusion mechanisms).

207

208 [Figure 1]

209

210 In figure 1, the five steps are visualized as a circular pattern around an organizational
211 improvement trajectory. The framework of Steiber and Alänge (2015) provides a validated
212 model for the digital innovation delivery process by which activities could be analysed or
213 planned. More recently, Steiber et al. (2021) explored the digitization process for industrial
214 firms, presenting a validated framework based on innovation diffusion theories and case study
215 evidence, with inhibitors and drivers of digital transformation being identified. As Steiber et
216 al. (2021) note, diverse theoretical perspectives and new research methodologies are needed in
217 order to understand the major challenges that block or hinder firms' deployment of digital
218 technologies. These insights reveal how there remains a need to understand the practice of
219 innovation ~~design, development and deployment~~ in clearer terms.

220

221 **Social Practice Theory**

222 Theodore Schatzki's social practice theory (1996; 2002) enables a domain to be examined as a
223 'field of practices' with ever evolving 'nexuses of doings and sayings' (Schatzki, 1996).
224 Although Schatzki (2001) notes that practice can refer to both individual performed activities

225 and a guiding principle for activities, Knorr Cetina (2001) observes that the majority of scholars
226 agree with the definition of practices as:

227 ‘recurrent processes governed by specifiable schemata of preferences and prescriptions’
228 (p.175)

229
230 Schatzki’s theory of practice (1996; 2002) is generally considered as one of 5 current
231 approaches to studying practice (other approaches being communities of practice; activity
232 theory; ethnomethodology and discourse analysis: Nicolini, 2012). Nicolini (2012) encourages
233 researchers to draw selectively on concepts from different approaches to illuminate various
234 aspects of practice, proposing a “toolkit approach” for empirical work. Such flexibility makes
235 practice theory a potentially attractive methodological approach, whilst also remaining
236 challenging. As Schatzki (2012) comments,

237
238 ‘The world according to practice theory offers much to investigate. There are practices,
239 arrangements, activities, bundles and constellations. There are questions about which of these
240 exist, when and where, their details, how they work and unfold, how they can be designed or
241 altered, and how to prepare people to enter them.’ (p.23)

242
243 Schatzki (1996) maintains that practice is a “temporally unfolding and spatially dispersed
244 nexus of doings and sayings, embracing notions of activity and organization” that make up
245 people’s “horizons of intelligibility” (Nicolini, 2012). Caldwell (2012) maintains that
246 Schatzki’s ambition is to ensure practices are ontologically more fundamental than language
247 and discourse: practice actions (the “doings”) taking priority over practice language (the
248 “sayings”). Consequently, Schatzki gravitates toward a concept of agency as “doing”,
249 underplaying the role of language and discourse (Schatzki, 2002); in this scheme verbal and

250 non-verbal signs are part of the “doing” of a practice rather than its principal components.

251 Schatzki therefore distances his theory from those of Bourdieu and Giddens by rejecting

252 Bourdieu’s concept of “habitus” and Giddens concept of “practical consciousness” (Caldwell,

253 2012).

254 Whilst practice theorists generally maintain the social as a field of embodied, interwoven

255 practices organised around shared practical understandings, the concept of “*field of practice*”

256 or “*site of the social*” (Schatzki 2001) distinguishes Schatzki’s theory from those of others (c.f.

257 O’Keeffe et al., 2015; Nicolini, 2012). This notion can best be described as the *context* within

258 which practices occur: a “fields of practice” analysis being one that: a) develops an account of

259 practices and/or b) treats the field of practice as the place to study the nature and transformation

260 of their subject matter. This ontology comprises an array of orders and arrangements of people,

261 artefacts and entities that constitute the organized activities of that place (Schatzki, 2001): the

262 practices within a context being made explicit to identify the “practice-arrangement bundles”

263 of which those practices are part (O’Keeffe et al. 2015). As Schatzki (2013) states:

264

265 ‘The coalescence of a practice involves some combination of (1) the emergence of common

266 rules (explicit formulations) in the light of which actors proceed, (2) the crystallization of sets

267 of prescribed or acceptable ends, tasks and actions, (3) the development of common practical

268 understandings, and (4) the distillation of common general understandings.’ (p.37)

269

270 With a social practice approach, examination of the digital innovation experience cannot be

271 understood separately from its’ context: that context being a “field of practices” within which

272 the innovation resides. As stated earlier, there is value in clarifying what constitutes a

273 supportive context for delivery of an innovation. Schatzki’s classifies the ‘organization of

274 practice’ into 4 concepts (Table 1).

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3 2754
5 276 [Table 1]6
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10 278 Referring to Table 1, an action belongs to a practice if it expresses one of the understandings,
11
12 279 rules or teleoaffective concepts that organize that practice, with activities forming a nexus in
13
14 280 that they are organised and connect together through such relations as causality and intentional
15
16 281 directedness (Schatzki, 2012, p.15). Of the above concepts, teleoaffectivities may be the most
17
18 282 difficult to conceptualise. It is best understood by conceding that separate practices possess
19
20 283 their own sets of acceptable and enjoined intentions, actions, emotions and moods (Schatzki,
21
22 284 1996, 101). In construction, intentions or goals are often influenced or directed by normative
23
24 285 and emotional behaviour (Caldwell, 2012, 290), with certain teleoaffectivities being associated
25
26 286 with specific practices. For example, a project team may express surprise and shock at a
27
28 287 supplier quote five times above the going rate. Teleoaffectivities are those emotions, moods
29
30 288 and actions that become associated with certain practices.

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37 290 For an innovation, teleoaffectivities (i.e. positive or negative reactions) are potentially
38
39 291 significant to the success or failure of the innovation. For example, surprise and joy at being
40
41 292 able to perform a task not previously possible would be a positive teleoaffectivity, whereas
42
43 293 frustration or confusion about innovation use would be a negative teleoaffectivity. Therefore,
44
45 294 developers must be aware of teleoaffectivities and build-in processes to ensure possible
46
47 295 negative reactions are mitigated. This can be done via engagement activities, workshops and
48
49 296 pre-piloting work.

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54
55 298 Schatzki (2002) also states that “human agency must be understood as something contained in
56
57 299 practices” (i.e. as the performance of doings and sayings that constitute the actions that
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300 compose practices” p.240). Similarly to Schatzi, Sewell (1992), a practice theory scholar,
301 understands practices as enacted schemas (i.e. generalizable procedures) that can be transposed
302 from one domain to another, but that also organise and constrain other schemas. This paper
303 takes forward these ideas and Schatzki’s ‘organization of practice’ concepts to investigate the
304 practice of digital innovation delivery on the BIM Risk Library.

305

306 **Methodological Approach**

307 Theoretical Positioning

308 Theoretically, the research may be categorised as “social-science based” and “process-
309 oriented” rather than “engineering-focused” ~~based~~-research (see Blomquist et al, 2020, p.6).
310 As a ‘theories-in-use’ contribution (Söderlund, 2004), the focus on project processes enables a
311 theory and its’ associated concepts to be applied and examined objectively. In this case, the
312 paper applies social practice theory and the concepts of Schatzki (Table 1) to understand the
313 process of innovation delivery, such an analysis taking into account the complexities of human
314 life (c.f. Cicmil and Hodgson, 2006, p.10). Such an examination of social processes at work
315 (i.e. how understandings, emotions and rules emerge, evolve and become formalized) addresses
316 the need for more fine-grained studies of the microactivities occurring, as noted by Blomquist
317 et al. (2010, p.7). Methodologically, this paper follows the lead of O’Keeffe et al. (2015) in
318 focusing upon the “doing” or “performance” of innovation, and the processes leading up to
319 such “doings” in a construction project management context.

320 Practical Details

321 Practically, in terms of methodological steps, Figure 2 presents the overall flowchart of work
322 from the BIM Risk Library project. A series of ‘legal artefacts’ associated with phases of work
323 activity are also highlighted: these legal artefacts being critical to the mobilisation of the

1
2
3 324 innovation. Methodologically, to conduct a social practice analysis of the work occurring, each
4
5 325 separate work activity was examined by the researcher using the ‘organization of practices’
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7 326 concepts of Schatzki (1996) (Table 1). This meant identification of how rules, understandings
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10 327 (both practical and general) and teleoaffectivities (emotive behaviours) manifested through
11
12 328 spoken dialogue, shared artefacts and plans of action to be taken forward. Sources of data
13
14 329 included notes from meetings, ~~and the~~ workshops with industry practitioners ~~taken by the~~
15
16 330 ~~researcher~~ that captured thoughts and reactions to the innovation by industry experts, and the
17
18 331 shared artefacts that played prominent roles in the innovation design and delivery journey (i.e.
19
20 332 collaborative agreements; data management workflow; user guide; software tool). —The
21
22 333 multiple meetings between research team and industry partners were recorded on a Trello
23
24 334 board, providing a further source of data. ~~, as did the artefacts that emerged as part of the~~
25
26 335 ~~innovation journey (collaborative agreements; data management workflow; user guide;~~
27
28 336 ~~software tool).~~ As will be noted, the shared artefacts, such as the collaborative agreements and
29
30 337 data ~~management~~ workflow formalised how the innovation would operate and function. A
31
32 338 post-pilot survey of practitioners and interviews with individuals provided a further source of
33
34 339 data for analysis. The researcher examined the data chronologically, in logical order, as noted
35
36 340 on the figure 2 flowchart of work activities. ~~The paper also presents the research findings in~~
37
38 341 ~~the same way.~~
39
40 342
41
42 343 Regarding the meetings and workshops with industry, attended by the researcher and captured
43
44 344 via notes, it should be noted that discussions (i.e. spoken words) between stakeholders revolved
45
46 345 around the functioning of the innovation, how it should/could be used and how it would
47
48 346 potentially impact (positively or negatively) ~~construction~~ project work practices. Whilst
49
50 347 acknowledging that such conversations and ‘messy talk’ ~~of professionals~~ are intrinsically a part
51
52 348 of collaboration using BIM (Dossick and Neff, 2011), the focus of analysis was the
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349 'organization of practice' concepts of Schatzki (Table 1) and how and when they manifested
350 themselves. As noted, this manifestation would be through spoken dialogue, shared artefacts
351 and plans of action to be taken forward. Such a microanalysis of processes takes into account
352 the complexities of human life for a practice-oriented study (c.f. Cicmil and Hodgson, 2006,
353 p.10): the deeper examination of interactions ~~occurring~~ also addressing the need for fine-
354 grained studies of the work occurring (Blomquist et al. 2010, p.7). As noted in the following
355 sections, the social practice analysis facilitated clarifications of how 'sayings' transform into
356 'doings' of innovation delivery and use; the preferences of practitioners leading to a provisional
357 'schema for innovation' for a construction context.

358

359 [Figure 2]

360

361 **Innovation Analysis**

362 The BIM Risk Library project commenced in 2019 under the Discovering Safety research
363 programme: a collaboration between the Thomas Ashton Institute (TAI, 2020), the University
364 of Manchester and the Health and Safety Executive (HSE), UK regulator of workplace health
365 and safety. Aiming to assist design and construction professionals to better manage health and
366 safety via proactive use of digital technologies and mobilisation of information resources via a
367 Prevention Through Design (PtD) approach (Yuan et al. 2019), research work resulted in a
368 novel BIM-based tool developed within a commercial cloud-based platform (the BIM Risk
369 Library). Four different companies, with a total of six separate construction projects partnered
370 with the research project. Each project agreed to use the innovation, formalizing their
371 commitment via signed collaborative agreements. The projects had an average duration of four
372 months, and ranged in type (i.e. residential; industrial; commercial; infrastructure projects). By
373 way of illustration, a screenshot of the BIM risk library tool is given in figure 3.

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6 375 [Figure 3]7
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11 377 Separate work activities of the BIM risk library are now examined in sequence, as shown on
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14 378 figure 2.15
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17 37918
19 380 *Steering Committee Formulation*20
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22 381 A Steering Committee was setup for the BIM Risk library composed of research project
23
24 382 stakeholders. A primary source of membership was the BIM 4 Health and Safety Group
25
26 383 (BIM4H&S): a UK industry group focused on digital technologies to improve construction
27
28 384 health and safety. This group was instrumental in work leading to the industry standard PAS
29
30 385 1192-6: 2018 'Specification for collaborative sharing and use of structured health and safety
31
32 386 information using BIM' (BSI, 2018): a working link with this group therefore being important
33
34 387 as the innovation addressed digital technologies to improve construction health and safety.
35
36 388 Frequent communication with the Steering Committee membership ensured that both *general*
37
38 389 *understandings* and *practical understandings* of the innovation were discussed openly from an
39
40 390 early stage. As research team ideas regarding the innovation evolved, these could be bounced
41
42 391 off Steering Committee members; such interactions being an essential social aspect of
43
44 392 innovation development. *Rules* around innovation use were also discussed and clarified with
45
46 393 industry figures in a collaborative way at meetings. Amongst the questions asked were: how
47
48 394 would the innovation impact existing project ways of working? What training and instruction
49
50 395 would be provided? And how long would the innovation be mobilised? How could data be
51
52 396 drawn from live projects and anonymised? These practical questions were critical for the
53
54 397 further development of the innovation. The Steering Committee were consulted are regular

398 intervals through the research project; the link being vital for *understandings* and *rules* of use
399 to emerge.

400 *Ontology and ERIC matrix*

401 A foundational idea of the BIM Risk Library was formulation of an ontology to map out the
402 elements that make up a risk scenario requiring specific treatments: the ontology concepts
403 being rooted in industry guidance and previous academic work in the field. Details of the
404 ontology and matrix are provided in Collinge et al. (2020b). The ontology embodied rules
405 regarding types of data to be collected and the relations between them. Validation of the
406 ontology and matrix came from the Steering Committee and BIM4 H&S group, which again
407 enabled *general understandings* and *practical understandings* regarding the foundational
408 ontology and its` conceptual underpinning to be reviewed, and confirmed as valid. The
409 research team made notes of such discussions at the time for future reference.

410 *Industry Workshops*

411 The ontology was mobilised in industry workshops to populate nine risk scenarios with relevant
412 treatments. The workshops affirmed the validity of the ontology and the overall approach of
413 the research; both *general* and *practical understandings* of the conceptual ideas being reviewed
414 and discussed by practitioners at the workshops. It should be noted that no contracts or
415 specialised procedures were required to set up the workshops: individuals joined through
416 professional interest and commitment to improving construction health and safety. Resulting
417 from the workshops, a dataset of 9 risk scenarios and 162 treatments were identified to
418 eliminate, reduce, inform, or control (ERIC) the risks covering four different stages of the
419 project lifecycle: preliminary design, detail design, pre-construction, and during construction.
420 The industry workshops maintained and consolidated the relationship with project
421 practitioners.

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3 422 *Prototype Innovation*
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6 423 The dataset of 9 risk scenarios and 162 mitigations provided the basis for the prototype
7
8 424 innovation: the dataset being saved as a comma-separated values (CSV) file. At this stage of
9
10 425 innovation development, it should be noted that *general understandings, practical*
11
12 426 *understandings* and *rules* regarding the innovation had been discussed several times over with
13
14 427 industry experts. *Rules* regarding innovation use had been captured in notes to be taken forward
15
16 428 into discussions with software developers. Both positive and negative potential reactions to
17
18 429 the innovation by designers and companies (i.e. *teleoaffectivites*) had also been remarked upon
19
20 430 several times over in meetings. The research team recognised the importance of addressing
21
22 431 these in the work going forward.
23
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26

27 432 *Software development*
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30 433 Following a review of BIM software providers on the market, one specific software vendor
31
32 434 was selected and a legal contract set-up between research partners and the vendor so the
33
34 435 ontology and dataset could be hosted on a BIM software platform via a specifically designed
35
36 436 interface (figure 3). This important step would allow a sharing of the innovation with industry,
37
38 437 facilitating further population of the library with data by designers working on multiple
39
40 438 projects. The contract with the software vendor was vital to this task: an insight here being the
41
42 439 need to reserve project funds for software development (if expertise/capability is not within the
43
44 440 research team).
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49 441 The software vendor contract formalized the *general/practical understandings* and *rules* of use
50
51 442 of the innovation, previously discussed in workshops, meetings, etc. Therefore, the “sayings”
52
53 443 around innovation use were formalized in written form: specific “rules” that were to be codified
54
55 444 into interface functionality of the software. For example, the preference to present project
56
57 445 designers with a series of optional treatments for different risk scenarios rather than definitive
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1
2
3 446 solutions was codified into interface use (see figure 3). Both *general* and *practical*
4
5 447 *understandings* and *rules* of use of the innovation were later to be made explicit in a printable
6
7 448 User-Guide for designers. *Teleoaffectivities* (emotive reactions to the innovation) could only
8
9 449 partially be addressed during this stage of work as the research team and software developers
10
11 450 attempted to predict possible positive and negative reactions when the innovation would be in
12
13 451 use. Further activities needed to be done to address such issues.
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16 17 452 *Innovation Piloting*

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20 453 Having developed the prototype, it was necessary to pilot it to validate work completed and
21
22 454 begin the process of collecting more risks/treatments. Piloting began in Summer 2020 with 4
23
24 455 industry partners and 6 projects. A dedicated support service was setup to assist pilot projects
25
26 456 with any questions they had about using the innovation – this service assisting with
27
28 457 *understandings* and *rules of use* questions. Whilst each pilot was uniquely different, they all
29
30 458 shared a common commitment to identify risks and improve health and safety. It was through
31
32 459 piloting that opinion of the innovation was collected, with positive and negative reactions being
33
34 460 captured via informal feedback and a more formal survey and interviews. Piloting was
35
36 461 therefore very important: changes and amendments to the innovation could be usefully actioned
37
38 462 prior to a much larger rollout to industry. By the end of the piloting phase (June 2021), a CSV
39
40 463 file containing 401 treatment prompts for 31 risk scenarios related to 11 different risk categories
41
42 464 had been added to the BIM risk library. A number of legal artefacts were associated with the
43
44 465 piloting work (figure 2). These are discussed in the following section.
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50 466 *Innovation Evaluation*

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53 467 Following piloting and collection of data over a 5 month period, an evaluation process was
54
55 468 initiated. A questionnaire survey and interviews with users provided opinions about the digital
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57 469 innovation. The interviews allowed more detailed opinions of the innovation from industry
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3 470 users of the innovation to be captured. Table 2 gives demographic information regarding the
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5 471 survey participants and interviewees.

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8 472 [Table 2]
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13
14 474 The survey revealed that 85% of experts agreed or strongly agreed that the innovation could
15
16 475 positively impact design decisions and support selection of appropriate treatments to mitigate
17
18 476 health and safety risks. Although 13 is not a large number of survey respondents, the positive
19
20 477 comments of construction experts validated the innovation. Furthermore, such a sample
21
22 478 number aligns with the guidance of Hallowell and Gambatese (2010), who note the value of
23
24 479 small sampling numbers, where a minimum of eight experts is recommended to validate a
25
26 480 research proposition. Furthermore, interviewees perceived that adding safety information to a
27
28 481 BIM model, and pinpointing risks added value to their -safety management processes. Another
29
30 482 benefit noted was the structured approach to inputting risk data and the opportunity for
31
32 483 collaborative work which the innovation enabled. As part of the evaluation, *understandings*,
33
34 484 practicalities of the innovation, *rules* of use and *teleoaffectivities* were all queried through
35
36 485 questionnaire survey and interview questions. For further information regarding the innovation
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38 486 survey, see Osorio-Sandoval et al. 2021). -

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44 487 *Publicity*

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46
47 488 The innovation was presented at several national and international events (e.g. Digital
48
49 489 Construction Week 2019; BIM for Water event 2019) and subsequently, won two prizes
50
51 490 (buildingSMART 2020; Construction Computing Award 2021): these prizes confirming the
52
53 491 value of the innovation to industry. Publicity is a vital aspect for any successful innovation,
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55 492 providing opportunity to communicate positive opinions and teleoaffectivity emotions about
56
57 493 an innovation to a wider audience.
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3 494 As noted on figure 2, several legal artefacts emerged as innovation work progressed.
4
5 495 Examination of the Collaborative agreements and Data Management Workflow provide
6
7 496 evidence regarding how an enactment of a distinct “schema” for innovation delivery became
8
9 497 tangible in written form and procedural guidelines.
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13 498 *Collaborative Agreements*

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15 499 Collaborative agreements between industry partners, the HSE and the University detailed
16
17 500 specific information and instructions concerning use of the innovation and creation of the BIM
18
19 501 Risk Library. These were approved by each party’s legal teams and signed by organisational
20
21 502 senior executives. The agreements covered issues such as data protection and anonymisation
22
23 503 of data shared with the library. Provision of free software pilot licences to cover the pilot
24
25 504 period and specific terms/conditions regarding long term use of data were also detailed.
26
27 505 Support to be provided to industry partners, including training and instruction to assist users,
28
29 506 and plug-in development to facilitate innovation use with different software packages were also
30
31 507 specified in the agreements. A Data Management Workflow (figure 4) visualizing the data
32
33 508 collection process for the BIM risk library was included in the agreements. With the
34
35 509 agreements we see a shift from innovation “sayings” to written formalisations of
36
37 510 understandings and rules of use, prior to actual “doings” taking place.
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44 511 As noted, the agreements formalise and make explicit the shared thinking around the innovation
45
46 512 (i.e. general/practical understandings of it; rules concerning its’ use) already established
47
48 513 amongst stakeholders; an absence of shared thinking being identified as potentially detrimental
49
50 514 to collaboration if not established (Aarseth et al. 2012). For innovation developers, obtaining
51
52 515 formal agreement to use an innovation is crucially important, so the language used to compose
53
54 516 the collaborative agreement needs to be worded correctly. The collaborative agreements meet
55
56 517 the points noted by Lokuge et al. (2019) as being important regarding organizational readiness
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3 518 for digital innovation: namely, resource readiness, IT readiness, cognitive readiness,
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5 519 partnership readiness, innovation valance, cultural readiness and strategic readiness.
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10 521 Additionally, the collaborative agreements brought order to the innovation process so that all
11
12 522 parties know their roles and responsibilities going forward, facilitating the transformation of
13
14 523 the digital innovation from a prototype to technology in use. The underlying parameters form
15
16 524 part of an “enacted schema” for innovation delivery (see Discussion), facilitating a collective
17
18 525 goal and creating a team ethos and general understanding of objectives (c.f. Uhl-Bien et al.
19
20 526 2007).
21
22

23 527

24 528 ***Data Management Workflow***

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26
27
28 529 Intrinsic to innovation development was the Data ~~Management~~ Workflow for retrieval, review,
29
30 530 anonymization and uploading of data to the BIM risk library. This workflow (figure 4) was
31
32 531 integrated into the Collaborative agreements and embodied in processual terms the *rules* and
33
34 532 preferences of practitioners regarding innovation use on their projects. For example, the
35
36 533 workflow details how risk scenarios and treatments inputted by pilot projects were to be
37
38 534 retrieved periodically from the cloud by the research team to be anonymized by removal of
39
40 535 sensitive or project-specific information. The overall workflow shows how data was to be
41
42 536 collected in a non-intrusive way: this being an effective and important provision of practitioners
43
44 537 using the innovation. The workflow was a necessary and informative device to re-assure
45
46 538 practitioners how the innovation would practically function, and how data drawn from projects
47
48 539 would input into the growing BIM risk library. It complimented and clarified information
49
50 540 given in the Collaborative agreements: clear communication on how an innovation will
51
52 541 function in the project management context being vital.
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1
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3 543 [Figure 4]
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8 545 The workflow also enacting the preferences of industry by defining the operation of the
9
10 546 innovation in a project management context: data security; non-intrusive interactions with
11
12 547 practitioners; a finite timespan of work activity; an easy to understand plan of action all being
13
14 548 clarified. These preferred preferences of innovation users can be understood as being part of
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16
17 549 the enacted schema for innovation delivery ([Figure 6Table 3](#)).
18

19 550
20

21 551 **Discussion**

22
23
24 552 The review of the BIM Risk library work activities, together with the collaborative agreements
25
26 553 and data ~~management~~ workflow evidences the presence of Schatzki's 'organisation of practice'
27
28 554 concepts (general/practical understandings; rules; teleoaffectivities – emotive behaviours) that
29
30 555 ~~together~~ -characterise a distinct practice. The evidence indicates how "sayings" regarding ~~an~~
31
32
33 556 innovation evolve into "doings" via formalised agreements and contracts between parties.
34
35 557 Such a transformation is necessary for companies operating in competitive and data sensitive
36
37 558 environments. Therefore, whilst the digital innovation journey has been recognised as an
38
39
40 559 "ongoing social accomplishment" pivoting around "negotiated interactions between the main
41
42 560 parties" (Bresnen, 2009, p.931), a social practice analysis brings greater clarity to the processes
43
44 561 occurring in terms of ~~the~~ human behavioural aspects underpinning an innovation. The findings
45
46 562 enable further reflections on the existing literature in terms of theoretical and practical
47
48
49 563 contributions.
50

51 564 **Theoretical Contribution**

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53
54 565 The social practice analysis of interactions and artefacts associated with the BIM ~~r~~Risk ~~l~~Library
55
56 566 innovation align with the framework of innovation diffusion of Steiber and Alänge (2015): the
57
58 567 five step process ~~of that model~~ (desirability; feasibility; first trial; implementing; sustaining)
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1
2
3 568 being evidenced on the BIM ~~r~~Risk ~~l~~Library ~~project~~ in terms of the work activities followed.
4
5
6 569 The social practice analysis adds a layer of detail to this framework in terms of how
7
8 570 understandings emerge, rules are established, formal agreements are made and emotive
9
10 571 behaviours manifest. With regards to Rogers (1995) six innovation-characteristics that matter
11
12 572 for its' diffusion in a social system (i.e. relative advantage for the adopter; compatibility with
13
14 573 existing system; complexity/difficulty to learn; testability; potential re-inventions; observed
15
16 574 effects), the social practice analysis provided ~~tangible~~ evidence of how each of these are linked
17
18 575 to shared understandings, rules and emotive behaviours. A key insight is the importance of
19
20 576 relational conditions underpinning innovation use and ~~the need for~~ good working relationships
21
22 577 between partners. That mutual dependencies can result in ~~instance of~~ friction, satisfaction or
23
24 578 other emotive behaviours (teleoaffectivities) is a reality when using an innovation. The various
25
26 579 work activities occurring prior to innovation launch established positive relational conditions
27
28 580 (formalised via the collaborative agreements). The empirical evidence suggests that digital
29
30 581 transformation is not the simple application of a new technology into a project context, but an
31
32 582 all-round transformation of project processes that connect with management, business and
33
34 583 organization methods. The paper illustrated how activities leading to innovation development
35
36 584 together with the collaborative agreements and data workflow provided a solid foundation for
37
38 585 ~~effective successful~~ innovation delivery.
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47 587 ~~It has been noted that~~ The interplay between ~~the~~ dynamic process of innovation use and more
48
49 588 routinized processes of project management work (Bygballe et al., 2016) ~~has been noted is as~~
50
51 589 an important one. The paper ~~insights~~ illustrates how this dynamic can be played out: the ~~BIM~~
52
53 590 ~~risk library~~ Data ~~Workflow Management Plan~~ (figure 4) linking to issues of importance for
54
55 591 practitioners under pressure to deliver work to time and budget whilst minimising disruption
56
57 592 to ~~existing~~ project processes. Innovation developers and practitioners need to enter into trustful
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59
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1
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3 593 relationships ~~in order~~ for innovations to be given a chance for success; legal artefacts like
4
5 594 collaborative agreements enable innovations to be tested, developed and deployed in
6
7
8 595 transparent ways. The insights from the BIM risk library of the paper enable the practice of
9
10 596 innovation delivery to be clarified (figure 5) in terms of how “sayings” transform into “doings”.
11
12 597 As a result, the construction context for innovation may be understood as a distinct “field of
13
14 598 practices” (Schatzki, 1996, 2001) with its` own distinctive schema of “preferences and
15
16 599 prescriptions” (Knorr Cetina, 2001) of developers and practitioners, as highlighted in figure 6.
17
18
19 600 Reference to such a schema is useful for both technology developers and innovation developers
20
21 601 addressing practicality issues.
22
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24 602

25
26 603 [Figure 5]
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29 604

30 605 ***Practical Contribution***

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32
33 606 ~~Whilst it has been noted that d~~Digital innovations demand changes to working practices (c.f.
34
35 607 Cicmil and Marshall, 2005), with new practices emerging as people coordinate in new ways
36
37 608 (Cicmil et al. 2006; Sage et al. 2012). ~~_-aA~~ social practice analysis clarifies how this happens
39
40 609 in actuality practice (in terms of understandings, rules and emotive behaviours). Such a study
41
42 610 extends understanding of the decision-making processes managers use in the adoption of new
43
44 611 technologies and ~~the~~ strategies used to deal with uncertainty (Mitropoulos and Tatum, 1999).
45
46
47 612 On the BIM Risk library, industry partners signed collaborative agreements following extended
48
49 613 periods of discussion with research partners, establishing their understandings and agreed
50
51 614 parameters of innovation use. Deriving from the BIM risk library, Ffigure 5 illustrates how
52
53 615 such discussions formalise into agreements prior to innovation use. As indicated in figure 5,
54
55
56 616 the practice of innovation delivery and its` associated sayings, doings and formalisations may
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617 be visualised to have a relationship within which the preferences of stakeholders are emergent,
618 formalised and enacted upon.

619

620 If we follow Knorr Certina's (2001) definition of practices as "recurrent processes governed
621 by specifiable schemata of preferences and prescriptions", we can begin to identify an
622 underlying schema ~~of preferences and prescriptions~~ for ~~digital~~ innovation delivery in
623 construction. Analysis of the BIM Risk Library assists in such a process and adds a level of
624 social understanding lacking in models such as the technology-acceptance model (TAM) that
625 fail to recognise user acceptance over time (Liu et al. 2018). ~~Figure 6 Table 3~~ draws together
626 insights from the empirical evidence to present an enacted schema for innovation delivery in
627 construction. It is contended ~~that~~ the schema should be reflected and enacted upon in order to
628 make an innovation successful in a construction context. Additionally, the schema addresses
629 the three tenets of Havenid et al. (2019) in a recent collection of works on innovation in
630 construction; these tenets being to shed light on the organisational processes within contexts of
631 innovation in construction; to apply novel theoretical perspectives to empirical phenomena,
632 and to recognise the temporal and spatial distribution of innovation as processual activities.

633

634 [~~Figure 6 Table 3~~]

635 ~~The figure 6 schema able 3~~ notes the prescriptions and preferences of developers and
636 practitioners for effective innovation delivery. ~~for both developers and practitioners.~~
637 Developer Pprescriptions ~~for effective innovation delivery~~ include clear definitions of the
638 purpose and /benefits of an innovation; clarity over roles/responsibilities of parties; clarity on
639 ~~and~~ how the innovation will work/function. ~~The p~~Preferences note aspects which would
640 support successful innovation deployment, including the social practice concepts of Schatzki
641 and the need to minimize disruptions to project work processes. A developer preference would

642 ~~be the Innovation developers should note the~~ importance of reducing negative emotive
643 reactions whilst promoting positive reactions if possible. ~~The Both~~ collaborative agreements,
644 ~~and data management~~ workflow (embodying general/practical understandings, rules and
645 purpose of the innovation), ~~and user guide~~ emerged as the project evolved ~~;~~ at a moment in
646 time that was ~~appropriate and~~ required for progression of the innovation. These artefacts of
647 innovation embody the prescriptions and preferences of developers and practitioners. These
648 are shown in figure X as emerging from the processes. ~~;~~ ~~The~~ various meetings,
649 communications and work interactions preceding their creation were important in preparing
650 ~~the~~ industry partners for the innovation itself and laying the groundwork for its' uptake.

651

652 **Limitations**

653 ~~A limitation of the paper is that the insights are drawn from one single study of innovation~~
654 ~~delivery. Whilst single case studies can be criticized from a data limitation point of view, it~~
655 ~~should be noted that 4 different companies used the innovation on 6 separate projects over~~
656 ~~several months. Therefore, the data upon which the study is based is not insubstantial.~~
657 ~~Additionally, as the innovation has garnered attention and won awards, it is contended that the~~
658 ~~insights of the paper are useful and informative for industry innovators and the academic~~
659 ~~community.~~

660

661 **Conclusions**

662 The paper advances understanding of successful digital innovation delivery in construction
663 project management through a social practice analysis of various activities and outputs
664 associated with one innovative technology (the BIM risk library): i.e. discussions; legal
665 agreements; innovation workflow; software artefact; user guide). A limitation of the paper is
666 that the insights are drawn from one single study of innovation delivery. Whilst single case

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3 667 studies can be criticized from a data limitation point-of-view, it should be noted that 4 different
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6 668 companies used the innovation on 6 separate projects over several months. Therefore, the data
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8 669 upon which the study is based is not insubstantial. Additionally, as the innovation has garnered
9
10 670 attention and won awards, it is contended that the insights of the paper are useful and
11
12 671 informative for industry innovators and the academic community.
13
14 672 Additionally, ~~the paper provided~~s tangible insights into how an innovation can emerge from
15
16 673 context-specific interactions (e.g. industry workshops; software vendor negotiations; piloting
17
18 674 work) ~~(Williams and Edge, 1996; Orlikowski, 2009)~~ where general and practical
19
20 675 understandings of an innovation, rules regarding its' use and teleoaffectivities (emotive
21
22 676 behaviours) are part of the discourse. Employment of Schatzki's 'organisation of practice'
23
24 677 concepts to examine the interactions occurring and the resultant artefacts shared between
25
26 678 collaborators highlight the importance of understandings, rules and emotive behaviours in the
27
28 679 innovation journey. Whilst the evolutionary nature of innovation development ~~(Linderoth,~~
29
30 680 ~~2010)~~ was described, a distinct 'field of practice' for innovation delivery came into focus, with
31
32 681 a 'schema of generalisable preferences' emerging from the social practice analysis (figure 6).
33
34 682 Artefacts such as legal agreements, software product and innovation workflow evidenced how
35
36 683 the innovation discourse shifts from verbal "sayings" to formulised agreements and contracts
37
38 684 that embody the preferences and prescriptions of practitioners: the practical realities of
39
40 685 innovation use being translated into a tangible schema prior to their "doing" in construction
41
42 686 project contexts. The ~~research~~ findings complement existing frameworks for understanding
43
44 687 innovation delivery in project management contexts, ~~building on the work of Steiber and~~
45
46 688 ~~Alänge (2015),~~ and provide an extension to the body of knowledge on factors contributing to
47
48 689 innovation delivery in construction.
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691 **Data Availability Statement**

692 Some or all data, models, or code generated or used during the study are available in a
693 repository or online in accordance with funder data retention policies
694 (<https://www.discoveringsafety.com/>).

695

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701

702 **Disclaimer**

703 The author reports there are no competing interests to declare.

704

705 **Ethics Statement**

706 The research obtained ethics approval from the University of Manchester Ethics Committee.
707 Subsequently, informed consent was received from the research subjects.

708

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Figure captions

879 **Fig 1.** Framework for diffusion of innovations

880 **Fig.2.** BIM risk library screenshot

881 **Fig.3.** Flowchart of work activities

882 **Fig.4.** Data management workflow

883 **Fig.5.** Practice of innovation delivery

884 **Fig.6. Schema for innovation delivery**

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Practical Understandings	Knowing how to execute desired actions through basic doings and sayings.
Rules	Formulated directives, admonishments and edicts; rules can be defined as “methodically applied generalizable procedures of action”.
Teleoaffectivities	Acceptable and enjoined emotions, moods and actions associated with certain practices.
General Understandings	Understandings or senses of general matters pertinent to goings-on in practices.

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Table 1: 'Organization of practice' concepts (Schatzki, 1996)

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Expert ID	Area of work	Experience in the construction industry (Years)
EXP-01	Design	45
EXP-02	Other (specify) <i>All stages</i>	41
EXP-03	Other (specify) <i>All stages</i>	40
EXP-04	Design	5
EXP-05	Other (specify) <i>All stages</i>	44
EXP-06	Strategic planning	15
EXP-07	Construction	33
EXP-08	Design	40
EXP-09	Construction	33

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EXP-10	Construction	49
EXP-11	Design	33
EXP-12	Other (specify) <i>CDM Principal Designer</i>	35
EXP-13	Design	28

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Table 2: demographic information of survey/interviewee experts

<i>Schema for innovation delivery</i>	
Prescriptions	
➤ Clear articulation of the purpose of the innovation and its' benefits.	
➤ Clear definition of the roles/responsibilities of participating parties.	
➤ Clear definition of how the innovation will work/function.	
Preferences	
➤ Provision of legally binding agreements between parties to ensure innovation is used/tested.	
➤ Provision of education/training for innovation use.	

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4	➤ Establish general understandings, practical understandings and rules of innovation use.
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6	➤ Minimise disruption to existing project work processes.
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8	➤ Guarantee confidentiality and data security.
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12	— For innovation developers
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14	➤ Reduce negative teleoaffectivities when possible.
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16	➤ Promote positive teleoaffectivities when possible.
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Table 3: Schema for innovation delivery

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