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Philip Dobson
Edith Cowan University, p.dobson@ecu.edu.au

Richard Fulford
Edith Cowan University, r.fulford@ecu.edu.au

Llandis Barratt-Pugh
Edith Cowan University, l.barratt_pugh@ecu.edu.au

Sue Bahn
Edith Cowan University, s.bahn@ecu.edu.au

Denise Gengatharen
Edith Cowan University, d.gengatharen@ecu.edu.au

See next page for additional authors

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Authors

Philip Dobson, Richard Fulford, Llandis Barratt-Pugh, Sue Bahn, Denise Gengatharen, and Ann-Claire Larsen

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Philip Dobson, Denise Gengatharen, Richard Fulford, Lllandis Barratt-Pugh, Susanne Bahn, Anne-Claire Larsen
Centre for Innovative Practice
School of Management
Edith Cowan University
Perth, Western Australia
(corresponding author: p.dobson@ecu.edu.au)

Abstract

Abduction plays an important but often unacknowledged role in research – this regrettably leaving a large part of the research process hidden and unexamined (Levin-Rozalis 2000), particularly important innovative or creative components. This paper, firstly, introduces abduction and discusses some important concepts related to abduction and innovation. Secondly, it presents author's own re-descriptions of previous research work. This new description seeks to describe perceived key "Eureka" moments in the research and thus make the creative components and abductive elements more visible. The paper demonstrates that much can be gained from opening a reflective space for the role of abduction in the research process.

Keywords

abduction, case studies, scientific method, pragmatism.

INTRODUCTION

> "The whole series of mental performances between the notice of the wonderful phenomenon and the acceptance of the hypothesis, during which the usually docile understanding seems to hold the bit between its teeth and to have us at its mercy, the search for pertinent circumstances and the laying hold of them, sometimes without our cognizance, the scrutiny of them, the dark labouring, the bursting out of the startling conjecture, the remarking of its smooth fitting to the anomaly, as it is turned back and forth like a key in a lock, and the final estimation of its Plausibility, I reckon as composing the First Stage of Inquiry" (Peirce 1908 cited in Paavola 2004a, p. 248).

For most researchers, their research processes are generally categorised as deductive or inductive whereby deduction focuses on confirming local application of theories and induction on determining generalization of local hypotheses. However, a third process, based around abduction, is likely to be the only approach capable of generating new concepts. Abduction plays an important role in much of research in that abductive reasoning is used, often early on in the research process, to generate a hypothesis for explaining a surprising or unexplained fact. Hoffmann (2010) distinguishes between two forms of abduction – selective abduction and creative abduction: "If this hypothesis exists already in our mind or in a database, we can call it "selective abduction," and if we have to create a new hypothesis—either a historically new one or one that is new for a student who learns something by discovery—we can talk about "creative abduction" (p. 42). Hoffmann builds on the suggestion that creativity is not a single "A-ha" or Eureka moment, but an incremental process involving a number of preceding unconscious phases where subjects come gradually closer to the hypothesis or solution.

Researchers generally neither acknowledge nor document the early role of abduction in the research process – what Peirce terms "the first stage of enquiry" - thereby leaving a large part of the research process hidden and unexamined (Levin-Rozalis 2000). Neglected, then, are possibly important innovative or creative components within the research process. This paper uses four IS case examples to highlight previously unacknowledged abductive elements and to speculate on the benefits of such clarification. The paper also seeks to determine the extent to which a "Eureka" moment represents the creative element of the research. The paper begins by exploring contemporary interpretations of Peirce's concept of abduction and abductive enquiry. It then presents four case examples where researchers reflect on past research and describe the previously unacknowledged

abductive element. By so doing, the creative and innovative elements are made more visible and the actual research process is made clearer.

ABDUCTION AND ITS CONCEPTS

The 19th century American philosopher Charles Peirce introduced a third form of logical inference alongside induction and deduction when he described abduction as the moment of creative inspiration when a researcher conceives of a hypothetical explanation for some empirical fact. The inference process is described as:

"The surprising fact, C, is observed. But if A were true, C would be a matter of course. Hence there is reason to suspect that A is true"   (Peirce 5.189).

In his mature writings, Peirce treats abduction as the first part of a three-stage logic of inquiry, the other two stages being deduction and induction:

"Abduction having suggested a theory, we employ deduction to deduce from that ideal theory a promiscuous variety of consequences to the effect that if we perform certain acts, we shall find ourselves confronted with certain experiences. We then proceed to try these experiments, and if the predictions of the theory are verified, we have a proportionate confidence that the experiments that remain to be tried will confirm the theory" (Peirce 8.209).

By way of incorporating abduction in the research process, Campos (2009) develops Peirce's ideas to argue for an important separation between the original flash of insight, and subsequent testing (termed Inference to Best Explanation (IBE)). He suggests that conflating the two is common in articles on abduction and unfortunately, thus, neglects differences between conjecturing hypotheses and testing them:

"Beyond the formal distinction between two forms of inference, we lose clear sight of the different aims of scientific reasoning - conjecturing versus evaluating - at different stages of inquiry. As a result, we also lose focus on providing a deeper account of hypothesis formation alone, apart from questions of the scientific assessment and evaluation of those hypotheses, once they have been proposed. We lose emphasis on thoroughly describing the mark of abduction - the act of bringing relevant, often innovative, concepts to bear in creative ways on the plausible explanation of previously unexplained phenomena" (p. 441).

Campos suggests that the initial abductive hypothesis generation is more concerned with the so-called "logic of discovery":

"The abductive suggestion comes to us like a flash. It is an act of insight, although of extremely fallible insight. It is true that the different elements of the hypothesis were in our minds before; but it is the idea of putting together what we had never before dreamed of putting together which flashes the new suggestion before our contemplation" (Peirce cited in Campos 2009, p. 429).

Campos (2009) builds on Hookway (1985) to specify Peirce's requirements for an abductive hypothesis: (i) to be explanatory, (ii) to be capable of experimental verification, (iii) to favour hypotheses that seem simple, natural, and plausible to us, (iv) to prefer theories that explain a wide range of phenomena to those more narrow in scope, (v) to be mindful of successful theories in other areas, that is, be mindful of analogies, (vi) to keep always present the question of economy of money, time, thought, and energy, (vii) to not unduly favour likelihood over plausibility (a highly improbable enquiry should not be rejected out of hand if it is deemed plausible for further enquiry).

Campos (2009) further describes Lipton's (1991) characterization of IBE as inference to the loveliest potential explanation rather than the most likely:

"From a Peircean perspective, the crucial distinction that Lipton is drawing implicitly is that we evaluate the likeliness of a hypothesis by way of inductive probability, while we evaluate its loveliness by way of explanatory plausibility. In evaluating inductive probability, we weigh the relative support that all of the empirical data provide for one or the other hypothesis; while in evaluating explanatory plausibility, we judge how well an explanation coheres with our current system of beliefs, that is, with our background theoretical knowledge, and with what we perceive or think to be possible" (p. 434).

Campos (2009) suggests that defining IBE as seeking the "loveliest" explanation better reflects the desire expressed within Lipton (1991) to seek "explanations that (a) specify a causal mechanism, (b) are precise, and (c)

unify our understanding and our explanatory scheme" (p. 435) (Peirce refers to "lovely" as increased "uberty"). Campos suggests that such a focus better reflects the actual abductive process in that plausible explanations are sought first rather than most likely; one then chooses for testing the hypothesis that provides the most potential for the deepest understanding.

Eco (1993) had earlier added further particulars as to types of abduction. He defines four types of abduction - overcoded, undercoded, creative, and meta. For Bertilsson (2004), overcoded abduction refers to the situation where the underlying hypothesis is obvious based on existing knowledge. Undercoded abduction, the current body of knowledge suggests, is a number of potential mechanisms and the researcher has to select the most plausible one given the specific context in which their cases are located. When engaging in creative abduction, the researcher has to invent the mechanism because no suitable one exists. This may result in some kind of paradigm change. Finally, meta-abduction refers to a series of mini-abductions to explain observed happenings. The abduction is more an abduction to facts rather than theory driven. Eco (1993) suggests this is similar to the role of a detective as one struggles through a sequence of proposed happenings to arrive, ultimately, at the significant creative abduction (Bertilsson 2004). For Hoffmann (2010) under-coded and over-coded abductions would be closest to selective abduction, with meta-abductions involving unspecified, perhaps creative or selective abductions.

THE CASE EXAMPLES

The case examples investigate the relationship between abductive enquiry and innovation. The research was initiated by a recently formed innovation research group seeking to highlight, formulate and promote innovation in research. As a first step, the group returned to investigate the innovation component of their own previously completed research. Their task was to reflect on the largely unacknowledged role abduction played in that research. The six team members came up with six case examples, two of which were related to evaluation research. The two evaluation research case studies, however, were excluded as the team felt that abduction was likely to play a different role in evaluative research that in other forms of academic research.

In most of the cases, the researchers acknowledged that the original research descriptions did not specifically acknowledge abduction, even though, in hindsight, they could see that important aspects of the research were clearly abductive in focus. The narratives presented below aim to address this neglect by "making visible" the largely unacknowledged abductive thinking behind each case. In particular, they identified the role that abduction played in the initial hypothesis generation. Perhaps surprisingly, all researchers came up with "eureka" moments in their research – all agreeing that the innovative aspect of their study was better described as a "eureka" moment rather than a gradual "dawning" of understanding. The case examples are written in the first person by each researcher.

Case Study One: Palliative Care Nurses Adopt Personal Digital Assistants

I became interested in computer-mediated communications (CMCs) in community nursing following the federal government's announcement that CMCs will replace paper based patients' notes. Much of the literature on CMCs in health care supported the change on grounds of improving efficiency. In contrast, there seemed to be scant information on either CMCs use in nursing and legal concerns or problems associated with CMCs use. I decided then to explore these issues empirically. The hypothesis I developed was: nurses adhered to legal and ethical obligations associated the CMCs to protect patients' information.

In 2008, a research assistant and I interviewed twenty community palliative care nurses about their use of personal digital assistants (PDAs). Though I had written four research questions for the research proposal, it became apparent early in the interviews that only the following two questions were relevant in the enquiry:

- What benefits and potential problems in communicating client information have hospice nurses identified since the ComCare mobile was introduced?

- What safeguards are in place to protect clients' privacy and confidentiality now that the ComCare mobile complements the paper-based home notes system? Are there issues that need addressing?

The interview data indicate that nurses' approaches to managing and reporting patients' information via PDAs are influenced largely by the need to protect themselves legally should they become embroiled in a court case. Patient notes were written, managed and stored in ways to satisfy nurses' understandings of legal requirements for protection. For example, the nurses had set up a 'zoning' system enabling them to communicate information to specific people only. Electronic notes as well as hand written notes, which had not disappeared, were managed in ways that would cover them legally. A typical response to questions about CMCs was, 'we have to do it this way because it's legal'. Thus, nurses care for palliative care patients in the shadow of legal concerns.

At this point it seemed obvious that Michel Foucault's work on regulation and its failures might be appropriate to explain how nurses and the virtual team are affected by regulatory requirements involving CMCs. I could have applied his concepts to this area of research and may do so at some point.

Instead, I abandoned this line of thought as something internal to the organisation seemed to be more important to the nurses rather than concern about external regulation. I discovered nurses had long standing legal and ethical obligations to protect patients' information. Unexpected was the intensity of concern about legal considerations regarding telephone calls, text messages, assessment procedures and recording systems including some hand-written notes for specific eyes only. These findings proved to be a eureka moment.

How was I to explain nurses' concern with legal issues when nobody mentioned statutes, codes of conduct or court cases? Yet their careful management of electronic information indicated serious concern about legal issues. I turned to Heidegger for help in explaining how and why legal concerns had risen to nurses' consciousness. Heidegger's concept of 'revealing' seemed appropriate as it placed technologies, that is, PDAs and CMCs, rather than only external regulatory requirements at the centre of the research inquiry.

An organisation's use of CMCs does not function in a social vacuum. I also needed to be guided by insights into the relationship between health care as a social institution or practice, and legal and ethical concerns. New questions arose for me about the role of law in institutions outside the criminal justice system. I turned to Habermas' sociological work on the rule of law in the public sphere. Initially I investigated his insights into communicative action but discarded this line of inquiry in favour of his insights into law and human rights issues. Applying Heidegger's and Habermas' concepts in the same paper seemed to gel.

A second 'eureka' or 'flash' moment arose when it became clear that PDAs were intruding in the nurse-patient relationship. How was I to explain this change? An additional hypothesis emerged: the relationship between nurses and patients was affected by the use of personal digital assistants in nursing. This insight was further examined and led to a journal publication.

I returned to Martin Heidegger's critical analyses of technologies in general. Though he was writing in the early post-war period, Heidegger's concerns about the inexorable 'advance' of modern technologies were prescient. Technologies and health care have become inseparable. Heidegger warned also that technological advances in general were dangerous in transforming how we perceive not only the environment but also our humanness and time. Consequently, I applied Heidegger's concepts – 'enframing', calculative ways of thinking, and distance and time – to assess whether they were also 'true' for CMCs use in community palliative care nursing. I couldn't imagine an area of work in which 'humanness and time' issues were more relevant. I argued that nurse-patient relationships were changing to accommodate PDA use. This aspect of the research is being presented in a forthcoming conference.

The case can be seen as demonstrating an example of an under-coded abduction with many options available for explaining the surprising findings. The researcher clearly fixes on the explanation with the potential for providing deep understanding of the situation.

Case Study Two: Outsourcing

This research involved a longitudinal study over five years of a large public organization that had outsourced its IT division. Early in the study, the IT Manager glowingly described the department as:

"On the practical side of delivering a service we were starting to shine; we were winning TQM awards; the quality of our service was very good, and we were getting accolades in the press; the cost of our service was benchmarked internationally in the top six in the world…. things were going very, very well".

Yet this seemingly efficient operation was outsourced. This fact came as a considerable surprise to me. In hindsight, I was in a state of what Peirce describes as "doubt". As a new PhD researcher my initial efforts to resolve that doubt were to see outsourcing as a consequence of the "outsourcing bandwagon" effect. This largely derogatory term suggests companies and individuals follow a form of "groupthink" without rational analysis; yet, such an argument seemed too simplistic and did little to help explain the mechanisms by which outsourcing ensued.

My doubt resolved when I came to see that outsourcing was primarily a consequence of an external social structure emanating from within the state government, which imposed pressure on the organization to outsource. Pressure was imposed via the ability of the State Premier to hire and fire CEOs of state run organizations. The argument was supported by the observation that the CEO had changed immediately prior to the outsourcing process. In the normal course of events it would have been difficult to verify this, as my research contacts were not senior enough to confirm or deny the speculation. The abductive proposal remained on hold until the past

CEO joined our University and allowed candid interview. This fortuitous happening allowed a confident identification of the macro to micro change mechanism and thus made me much more confident in the validity of the hypothesis.

I recall that the above analysis depended on my appreciation of structure and agency in analysing social situations. Such a realization is likely to be seen by those trained in social science as rather elementary; yet, for me the appreciation of this separation was an astounding explanatory tool. For me, this was very much a "eureka moment". This basic realization provided a new way for me to reflect on social situations and allowed me to categorize much of what I had been struggling with. It allowed me to appreciate that the concept of representing the outsourcing as a form of groupthink suggested a more micro focused argument – in the case being examined this was less relevant in that the decision was imposed from above. An analysis involving structural imposition had more relevance to my area of interest and better explained observed happenings. The study could then have been further developed by perhaps examining "groupthink" at the governmental level but this was considered unachievable given the time frame and resources available.

Again the case reflects an under-coded abduction. The initial eureka moment is intimately related with theoretical re-description as well as case context. The initial hypothesis remained a hypothesis on probation for some time until the final confirming interview.

Case Study Three: The Adoption of Regional E-marketplaces

In 2003, government-sponsored regional Internet trading platforms for small and medium enterprises (SMEs) were emerging phenomena. These platforms were designed to introduce SMEs to e-commerce and online trading. In assessing the success and evaluating the benefits of 3 such platforms in Western Australia under an ARC scholarship and, in the absence of any one grand theory to fully explain their benefits or success, I drew upon the constructs of various theories in related areas to derive a conceptual framework of possible factors. These were used to investigate the phenomena via a predominantly interpretivist structured case study method with an embedded design that involved 66 interviews. The study 'flirted' with critical realist concepts as well as it did not sit comfortably with an interpretive approach alone.

The theoretical areas I drew upon were theoretical approaches to e-marketplaces, portals and virtual trading communities; diffusion of innovation theory; resource-based theory; stage theory; the theory of planned behaviour and the Technology Acceptance Model; institutional theory and partial, hybrid and integrated models of ICT and e-commerce adoption by SMEs and the DeLone and McLean (2003) IS success model. The factors were characterised according to four contexts viz. that of the platform owner, the SME participants, the technology or platform itself and the environment. The phenomena had social, political, economic and technological implications and influences and based on the current (albeit limited) knowledge, the benefits arising from such platforms were hypothesised to be categorised according to transactional benefits and strategic benefits at the individual, organisational and industry levels; and economic, community and strategic benefits at the regional level.

The first case was in suburban WA and though time, money and effort were expended over a number of years, the portal failed. It was owned by a consortium of local governments, a university and the local business associations with the purpose of growing the region for the local small businesses. In this first case I also used action research as a participant observer, gaining an insider's view. Although there were a number of mechanisms suggested by the existing body of knowledge that could be used to explain the lack of success (the perception of inadequate funding, the institutional bandwagon effect of wanting to look progressive but lacking commitment to do so, the 'what's in it for me' mechanism that led to a lack of cohesion among the consortium members), I was uneasy about attributing lack of success to any one factor (or combination thereof) at that point, as there were similar portals in regional WA which surprisingly appeared to 'be more successful'.

The second case was in regional WA and was formed by a few interested business and community members. At the time the platform in the first case failed, the portal in the second case was considered a success (success being defined as managing to keep operating with some cash from participation fees and some in-kind contributions from the community). Although it had received almost as much funding as the first case at the time, due to a political situation it was to receive a financial boost which would allow it to move operations along. It was, however, difficult to see it progressing to become commercially viable. Many participants supported the endeavour given its local grassroots origin but support in some quarters was beginning to wane as individual financial benefits from participation were not forthcoming. Based on some of the comments from participants (e.g. 'we must support the local endeavour', 'it would be a good thing for the region'), and the feeling of being welcomed by the portal owners and SMEs willing to meet me and be interviewed, I had a hunch that the 'success' of the portal had something to do with the culture of the region and that any benefits so far

attained had more to do with the 'feeling of community' that the endeavour had fostered rather than any had economic benefits.

Even more surprising, the platform in the third case, which was also in regional WA (though more rural than case two), was a bottom-up grassroots endeavour that had received the least funding among the three, was strongly supported by the local community. The platform, though, was not commercially viable despite some SME participants having paid more in fees (compared to SMEs in the portals in cases 1 and 2) to be listed on the portal without any financial return to date. One SME had paid up to A$1,000 but concluded "it was a good learning experience" and praised the local efforts of trying to improve the lot of the region and other SMEs who were more suited to obtaining benefits from such technology.

For cases two and three it was suggested that local support (i.e. the collectivist culture of the country folk) allowed these home-grown efforts to remain successful while their suburban counterpart 'failed'. This was not something that the many initial theoretical constructs pointed to. In fact in other studies uptake of e-commerce typically was higher in urban as opposed to rural areas and cultural factors were not generally discussed. Thus, it was decided to adopt institutional theory to safely account for the different results from the urban versus the regional portals.

In hindsight I see this as my "Eureka moment". It allowed an initial abductive hypothesis proposing a closer examination of the role cultural factors played in the implementation study. In using sub-culture to re-examine the portals, I found that although the portals in the regional areas were not commercially or economically viable, the collectivist culture of wanting the region to prosper and advance (sometimes at the expense of personal financial gain) caused the community to support the portal and participate in it. In the urban portal, the individualistic nature of the community and stakeholders meant that everyone was looking out for their own interests and even though some SMEs participated for free, they still had a lot of negative comments to make about the lack of any personal financial gain from the portal.

In terms of the development of the study an earlier recognition of abduction and its role would have made the process less stressful and more focused in that movement from data to hypothesis would probably have led to an earlier understanding of cultural aspects. Again this case reflects an under-coded abduction - many choices for explanation were possible with institutional theory focusing on cultural factors the most "lovable" in terms of providing a deeper, richer understanding and analysis possibility. A more "likely" explanation could have been founded around considerations of financial benefit. However, this explanation seemed to provide less opportunity for deep understandings.

Case Study Four: Financial Controls Within Construction Management

In 2010 I was undertaking case study research concerning the financial controls for very large-scale infrastructure projects. The organization under study was managing one of the largest construction projects world-wide and was concerned with the observed poor productivity from their financial management of project controls. The usual process of understanding the normative theory and principles led the study towards an inductive study of IS, costing methods and accounting practices.

While collecting data for the project, a eureka moment changed the very nature of the study. The abductive process was borne from a single statement made by the financial controller of the project, "we are analysing the project to two or three levels below where we need to and it is costing millions". The comment initiated a thought process that perhaps the poor productivity evident was a consequence of poor reporting and collaborative processes, rather than a deficiency in cost accounting or financial controls. The initial suggestion was that controlling expenditure at too low a level was taking up too many resources. The project is one of the largest worldwide and traditional reporting of expenditure was seen to be too detailed to provide an effective management tool. It was hypothesised that better aggregated reporting systems would help to address the poor productivity.

Following these insights the initial study was abandoned and a new research study began. The new study investigated the manner of organisational collaboration in the construction industry and how the processes can be better supported by integrated information systems. The study was very rewarding and provided not only an understanding of the deficiencies of information systems within the construction industry, but it also enabled a fertile platform for future research.

The case example can be seen as a sequence of abductive proposals derivable from the original productivity problems to an investigation of financial controls and then to aggregated reporting functions. The study seemed to be more a progressive investigative examination rather than heavily founded on particular theories. Perhaps meta-abduction best describes the process as a sequence of abductions is proposed not unlike a detective's investigative process.

DISCUSSION

The four researchers appreciate the benefit of explicitly recognizing the abduction aspects of their research. The process of seeking abductive elements made the research process clearer and in some cases highlighted particular shortcomings in the original case logic arguments. Other understandings gained in the process were that the separation of the original abductive leap from the IBE "testing" phase was useful. In the majority of cases the original abductive leap tended to focus on theoretical positions and more towards the most "lovely". Once this, often theoretical, leap was made, subsequent IBE tended to focus on the best mechanism-based explanation within this theoretical position. This argument is in contrast to that of Lipton (1991) who suggests that the initial abduction seeks plausible explanations that are then refined via IBE to the most "lovely". In our cases the core of the research builds on the original "lovely" choice, IBE then refining the explanation in context. An argument could be made that the precursor to the original leap is more complicated than that defined in our case examples. A number of miniature abductions that emerged were inadequate theoretical positions. Consequently, explanations were considered but then discarded. Yet documenting such research musings seems superfluous to the core of the research. In the process of defining a research proposal many unproductive avenues are investigated that generally do not merit documenting. In our view the core research process is best represented as an initial "lovely" proposal followed by subsequent testing for most "likely".

The separation of IBE and abduction was useful in allowing a better representation of the innovative aspects of the research. The PDA case study involved an initial important recognition of surprising phenomena in terms of the structured "legal-oriented" nature of nurse's reporting. Similarly the outsourcing case example depended on an initial surprise at the department outsourcing. The emarketplace case examination depended heavily on a recognition that rural adoption was significantly different from urban experiences. The construction management research was prompted by recognizing that productivity performance was comparatively poor in the sector. The determination of "wonderful phenomena" was an important pre-cursor to the research process in all cases.

The four different cases can also be seen to support Eco's categorizations of abductive types. The PDA case study and the emarketplace did not allow a simple explanation of observed happenings - these can be seen to be under-coded in terms of abductive possibilities. For the outsourcing case example und er-coding again seems most relevant in that the outsourcing case can be represented from many different perspectives. Also for this case it was useful to separate the initial abductive process and the subsequent IBE process - the final confirming interview with the Managing Director completed the lengthy IBE as macro-level imposition was finally confirmed. As detailed in Table 1, in all four case examples we can see researchers gravitating towards the "lovely" explanation rather than the most likely. Given the focus of academic research on publications and ongoing research this is perhaps not surprising.

Table 1: Case Summaries

Case Example	Type of Abduction (Bertilsson 2004)	"Eureka" moment?	Abduction seeks the most "Lovely" explanation or most likely?
Palliative Care	Under-coded or meta, the research reflected a number of successive abductive "events"	Yes, firstly in terms of preferring Heidegger to Foucault for explanation and secondly in appreciating the important role of PDA technology in the process.	The research was always focused on deep understandings rather than superficial
Outsourcing	Under-coded in that there were many possible ways of examining the change process.	Yes, in terms of theoretical re-description. The realization that "macro" and "micro" elements within the study provided explanatory power was foundational to subsequent research.	The research did not subscribe to prominent suggestions that the outsourcing was solely a consequence of a "bandwagon" effect – it was felt that this explanation was too shallow
E-marketplace	Under-coded in that there were many possible ways of explaining uneven adoption patterns.	Yes, the realization that there was a "macro" cultural level impacting factor that provided strong explanatory power.	The research did not follow a financial explanation for adoption differences – it was felt there was a deeper, more generalizable, cultural component.
Construction Management	Meta, in that the process was very much examining facts and proceeded as for a detective seeking "factual" answers.	Yes, a single statement within one interview prompted the course of subsequent research.	The ongoing research did not accept that the project was hampered by poor accounting procedures – it saw the problems as involving a deeper, more foundational communication problem within the project.

CONCLUSION

A major criticism with abduction is that the abduction process as described by Peirce suggests that all kinds of "wild and crazy hypotheses" are possible, yet, as Paavola contends, this is not actually the way that abduction is generally applied (Paavola 2004b, p. 268). As Paavola suggests, and our case examples demonstrate, abduction generally takes place within a framework of existing ideas. This approach tends to negate such criticism:

"The force of abductive inference is much strengthened if one takes into account that the hypotheses are to be searched for in relationship to various phenomena and background information and not just in order to explain one, surprising phenomenon" (Paavola 2004b, p. 270).

As the case examples demonstrate major stages in the research process involve (a) recognizing anomalies, (b) describing the solution type or framework of ideas required to explain these anomalies and (c) fitting the hypothesized solution within this overall framework of ideas. As Paavola (2004b) describes, representing abductive enquiry as a strategic process is important as it helps to address criticisms of abductive inference as a *logic* of discovery. By presenting abduction as one element within a strategic process one can strengthen the claims for abduction as an important part of the discovery process.

The case examples re-described also demonstrate the usefulness of reflecting on the abductive process to enable a better understanding of the research development. As Schurz (2007, p. 204) suggests the abductive process provides an important search strategy:

"The essential function of abductions is their role as search strategies which tell us which explanatory conjecture we should set out first to further inquiry (cf. Hintikka 1998, p. 528) - or more generally, which suggest us a

short and most promising (though not necessarily successful) path through the exponentially explosive search space of possible explanatory reasons".

All case study authors indicate that adopting a clear abductive process during their initial research would have helped with directing and perhaps shortening the research process.

The case examples also demonstrate the usefulness of separating the initial abduction from the ongoing IBE. By separating the initial abductive "eureka moment" from the ongoing IBE it was easier to appreciate the core creativity of the research and to better understand the research process.

It was also evident to the researchers involved that the initial hypotheses generated were always seeking a deeper, more generalizable, "lovely" understanding rather than the most "likely". Even though abduction was not explicitly recognized we are reassured that experienced researchers gravitate towards effective hypotheses without the discipline of abductive thinking.

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