Chapter 3
Knowledge Visualization for Research Design:
The Case of the Idea Puzzle Software at the University of Auckland

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ABSTRACT

This chapter presents a case of information and communication technology use in doctoral research processes. In particular, it presents the use of the Idea Puzzle software as a knowledge visualization tool for research design at the University of Auckland. The chapter begins with a review of previous contributions on knowledge visualization and research design. It then presents the Idea Puzzle software and its application at the University of Auckland. In addition, the chapter discusses the results of a large-scale survey conducted on the Idea Puzzle software in 71 higher education institutions as well as its first usability testing at the University of Auckland. The chapter concludes that the Idea Puzzle software stimulates visual integrative thinking for coherent research design in the light of Philosophy of Science.

INTRODUCTION

This chapter describes a knowledge visualisation tool – the Idea Puzzle software – for the overall design of a research project. The Idea Puzzle framework was created by the first author in 2007, in response to doctoral candidates' scepticism that they could share the same course on research design despite their heterogenous disciplinary background. The tool is based on Philosophy of Science to allow a visual overview of a research project beyond restricted notions of research design as method or fieldwork. Between 2007 and 2017, the first author presented the tool in 231 seminars, having received 1004 responses to an online anonymous feedback questionnaire. In 2009, the first software version of the tool was made available online, being licensed to higher education institutions (HEIs) since 2012. In 2016, the Academy of Management Learning and Education (4.235 5-Year Impact Factor) considered the Idea Puzzle software "a very useful tool for research across a multitude of disciplines, not only for PhD students as they learn about all of the elements of research project design, but also for reviewers and research project teams" (Parente & Ferro, 2016, p. 645). In 2017, the second author conducted the first usability testing of the Idea Puzzle software at the University of Auckland which subsequently led to the acquisition of its licence by the School of Graduate Studies. Congruent with such a chronological line, this chapter begins with a review of previous contributions on knowledge visualisation and research design. It then presents the Idea Puzzle software and its application at the University of Auckland. The chapter follows with an analysis of the issues identified in the large-scale survey and usability testing mentioned above, and concludes with solutions for the issues identified and suggestions for future research.

BACKGROUND

In recent years, there has been an unprecedented interest in the visualisation of academic research processes (Meyer, Höllerer, Jancsary, & Leeuwen, 2013). Previous contributions have focused, among others, on the practical visualisation of scientific knowledge (Worren, Moore, & Elliott, 2002), on the complementarity between visual formats (Eppler, 2006), on the disciplinary background of visualisation research (Eppler & Burkhard, 2007), on the visualisation of conceptual frameworks (Leshem & Trafford, 2007), and on the pitfalls of visualisation (Bresciani & Eppler, 2015). Taken together, such contributions have shed light on the origins, differences, and implications of visual representations in academia.

However, previous research on visualisation has neglected the overall design of a research project as a crucial stage of scientific practice. In the words of Meyer

et al. (2013), "we should aim at actively making use of the potential of visual representations to enable better research processes and results. This starts at the stage of designing projects" (p. 536). Such a research gap is relevant because the overall design of a research project is more complex than that of its constituent parts, requiring holistic and immediate visualisation as a complement to linear and sequential verbalisation (Meyer et al., 2013).

The purpose of this chapter is therefore to present a visual decision-making tool – the Idea Puzzle software – that supports the overall design of a research project. In the words of Parente and Ferro (2016), it is "a support tool to assist PhD students and researchers in the process of designing research projects through a focus on three central dimensions of research that are collectively represented by a triangle" (p. 643). Parente and Ferro (2016) further emphasise the visual dimension of the Idea Puzzle software as follows:

Our students repeatedly commented that using Idea Puzzle contributed significantly to their understanding of the meaning of the multiple and interrelated dimensions of the research project process. In addition, they applauded the functionality of having an automatic evaluation of their input into each section/piece of the triangle allowing them to control the development of the project design, as well as to decide which points they should invest more time into to build the final "puzzle" (i.e., visual representation) of their research project. (p. 644)

The two following sections thus review previous contributions on knowledge visualisation and research design, with a particular emphasis on the jigsaw puzzle metaphor and on Philosophy of Science, respectively.

Knowledge Visualisation

According to Eppler and Burkhard (2007), "the emergent field of knowledge visualisation examines the use of visual representations to improve the management of knowledge on all levels" (p. 112). An example of a knowledge visualisation format is the visual metaphor whose main feature is the dual function of a) positioning information graphically to organise and structure it; and b) conveying an implicit insight through the characteristics of the metaphor employed.

Eppler (2003) argues that visual metaphors are powerful templates for experts to communicate their knowledge with non-experts, giving the example of philosophers of science such as Aristotle, Hume, Ockham, Popper, and Wittgenstein. In particular, Aristotle regards the metaphor as a tool of cognition which "provides rapid information and is to the highest degree instructive" (Eppler, 2003, p. 82). Concrete examples of metaphors include Ockham's Razor, Hume's Fork, Popper's Bucket,

and Wittgenstein's Ladder. Interestingly, Wikipedia considers Ockham's Razor the only scientific law of Philosophy of Science named after a person.

Visual metaphors for knowledge transfer or creation may be natural objects such as an iceberg or human-made objects such as a jigsaw puzzle. The invention of the jigsaw puzzle is attributed to John Spilsbury, a London cartographer and engraver who commercialised sawed pieces of wood with the shape of national boundaries for the teaching of Geography (Hannas, 1972). The jigsaw puzzle is therefore a human-made object created for educational purposes. It is not surprising, therefore, that the jigsaw puzzle metaphor is recurrently employed in academia to research phenomena as diverse as curricular integration (Pearson & Hubball, 2012), environmental uncertainty (Sarasvathy, Dew, Read, & Wiltbank, 2008), and mobile application development (Danado & Paternò, 2014).

Eppler (2006) compared systematically visual metaphors with three other types of mapping methods – concept maps, mind maps, and conceptual diagrams – recommending their combined uses in four didactic steps. In particular, the author recommends empty conceptual diagrams for joint in-class concept development, mind maps for in-class individual note taking, concept maps for individual reviewing at home, and visual metaphors for joint in-class summaries.

In terms of systematic comparison between the two joint in-class mapping methods, Eppler (2006) considered conceptual diagrams appropriate for concise overviews, structuring of a topic into systematic building blocks, and application to a variety of situations in the same manner, whereas visual metaphors are appropriate as a mnemonic aid, to draw attention and curiosity, and to facilitate understanding by triggering functional associations. In terms of drawbacks, conceptual diagrams may be difficult to understand without knowledge of the category meanings, do not provide mnemonic help, and do not foster creativity or self-expression, whereas visual metaphors cannot be easily modified, may trigger wrong associations, and may be misunderstood.

From such a discussion, it is possible to conclude that the Idea Puzzle software employs a jigsaw puzzle metaphor in the shape of a triangle, with 21 jigsaw pieces (*Figure 1*). The jigsaw pieces, in turn, represent five systematic building blocks – theory, method, data, rhetoric, and authorship – which can be difficult to understand without knowledge of their category meaning. The following section thus reviews the development of the Idea Puzzle framework since 2007 in the light of previous contributions to research design.

Research Design

According to Creswell (2009), research design is a plan or proposal to conduct research which "involves the intersection of philosophy, strategies of inquiry, and

Figure 1. Idea Puzzle framework
Source: www.ideapuzzle.com
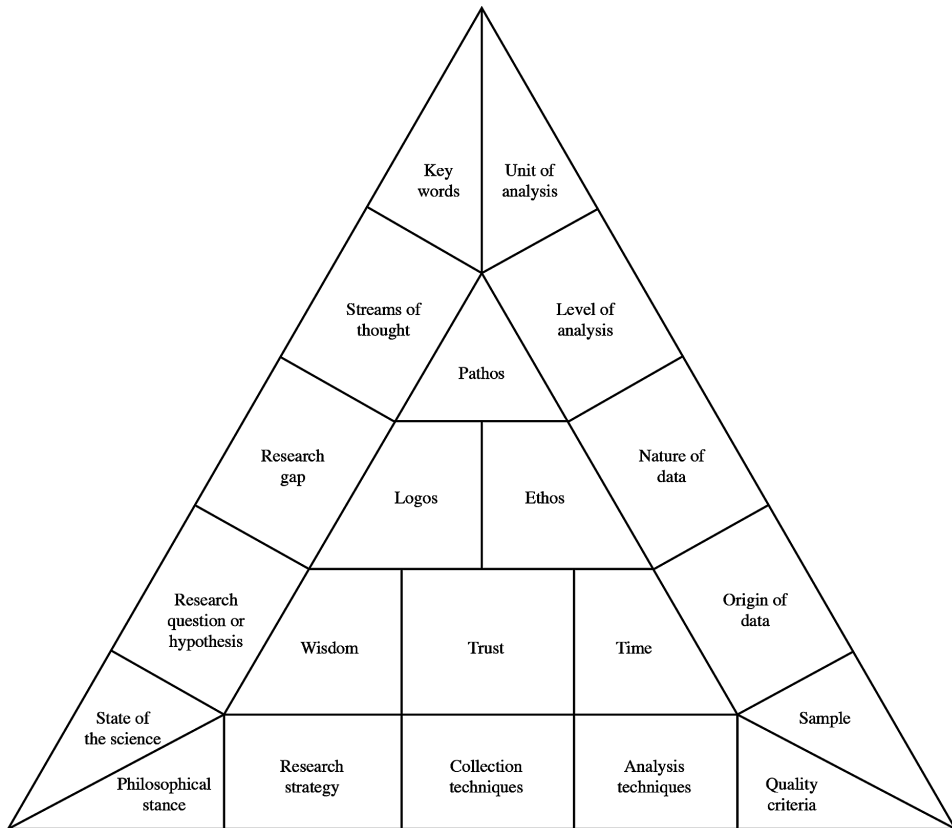
specific methods" (p. 5). The author proposes a conceptual framework for research design which, correspondingly, adopts the format of a triangle based on the three elements described above – philosophical worldviews, selected strategies of inquiry, and research methods. Such a triangular view of research design is thus restricted to method at the level of philosophical stances, research strategies, and techniques for data collection and analysis. An even more restricted view of research design is espoused by Leshem and Trafford (2007) and Layder (2013), who equate research design with fieldwork.

Brinberg and McGrath (1985) also propose a triangular conceptual framework for research design – the Validity Network Schema – under the assumption that "research involves three interrelated but analytically distinct domains: the conceptual, the methodological, and the substantive" (p. 15). Such a view of research design is

more holistic than the one by Creswell (2009), since it relegates method to one of the three elements of empirical research.

The triangular format of the Idea Puzzle framework (Parente & Ferro, 2016) is based on Brinberg and McGrath's (1985) Validity Network Schema. In particular, the left side of the Idea Puzzle triangle corresponds to the conceptual domain (theory), its bottom side to the methodological domain (method), and its right side to the substantive domain (data). In the words of Parente and Ferro (2016), "each side of the Idea Puzzle triangle corresponds to one of the three dimensions that every empirical research project should ideally include: ontology (data), epistemology (theory), and methodology (method)" (p. 643).

Huff (2009) took an even more holistic view of research design than Brinberg and McGrath (1985) by proposing a conceptual framework with six major decisions: ontology/epistemology, discipline/profession subfield, literature review, policy/ practice, model(s)/explanation/theory, and method(s)/context. In particular, the author claimed that "specific research design decisions in the areas listed (and others as well) must help you depart from what is currently known to your audience, while staying close enough to their interests that your contribution is recognised and valued" (Huff, 2009, pp. 86-87). Such a view emphasises the importance of relevance for academic audiences. Van de Ven (2007) similarly emphasised the importance of relevance, but for both academic and non-academic audiences through the Aristotelian notion of rhetoric. The Idea Puzzle framework (Parente & Ferro, 2016) thus follows Van de Ven (2007) by adding rhetoric to theory, method, and data, as a fourth building block in the upper inner part of the triangle.

At the individual level, Huff (2009) emphasised the importance of personal and professional experience for research design. She describes such an association as follows: "It has taken me a long time to discover how my 'ordinary' life could or should inform my academic life. Gradually, I have drawn more explicitly on experience outside of academia" (Huff, 2009, p. 22). In similar fashion, the Idea Puzzle framework (Parente & Ferro, 2016) considers the alignment between the research design and the author's personal and professional experience as a fifth building block – authorship – visually represented in the lower inner part of the triangle.

The Idea Puzzle framework thus adds two elements – rhetoric (Van de Ven, 2007) and authorship (Huff, 2009) – to the triangle between theory, method, and data suggested by Brinberg and McGrath (1985). In the light of Philosophy of Science, such five elements generally correspond to epistemology (theory), methodology (method), ontology (data), rhetoric (axiology of the audience), and authorship (axiology of the author).

The Idea Puzzle framework was created by the first author in 2007, in the context of an interdisciplinary course on research design for doctoral candidates of Mathematics,

Engineering, and Social Sciences. In that particular course, doctoral candidates were sceptical that they could share the same lectures given their contrasting scientific disciplines. As the sole facilitator of the course, the first author reassured the participants that Philosophy of Science (Riggs, 1992) was common to any scientific discipline and created the Idea Puzzle framework of 21 decisions (Parente & Ferro, 2016) to engage them in a common research design challenge. The feedback was positive and the first author received invitations by methodological teachers, deans of Graduate Schools (GSs), research deans, and even university rectors to lecture the same framework to interdisciplinary audiences in other universities and countries.

The point of departure for the Idea Puzzle framework were five methodological decisions – "philosophical stance", "research strategy", "data collection techniques", "data analysis techniques", and "quality criteria" – inspired by the macro structure of John Creswell's (1998) book on five approaches to research design. Such a macro structure is path-dependent in the sense that prior decisions (e.g., philosophical stance) limit the range of options available for subsequent decisions (e.g., research strategy).

Such a funnelling logic can, however, be applied to other than methodological decisions. In fact, the first author soon realised that teaching research design without reference to the theoretical and empirical context of the research project was pedagogically counterproductive. He therefore added five theoretical decisions and five empirical decisions to the initial five methodological decisions.

The five theoretical decisions help doctoral candidates focus a literature review in terms of two "keywords". Such two keywords limit, in turn, the range of "streams of thought" to review. Experts within the streams of thought will suggest, in turn, avenues for future research ("research gap"), thus legitimising a certain "research question or hypothesis". The result of such a funnelling sequence of theoretical decisions is a synthesis of the current answer to the research question or the hypothesis ("state of the science").

The five empirical decisions, on the other hand, help doctoral candidates focus their discussion of evidence in terms of a "unit analysis" at a certain "level of analysis". Such unit and level of analysis will be documented, in turn, with qualitative or quantitative data ("nature of data"), based on primary or secondary sources ("origin of data"). The result of such a funnelling sequence of empirical decisions is a set of one or more examples of the unit of analysis ("sample").

Taken together, the 15 theoretical, methodological, and empirical decisions can be visualised as a triangle that reflects the dilemmatic nature of the research process (McGrath, 1981) and the need for a permanent interplay between the research question or hypothesis, the research strategy, and the empirical sample (Brinberg & McGrath, 1985). In particular, recent topics are expected to involve fewer streams of thought and exploratory research questions, thus requiring qualitative research strategies and small samples. Mature topics, on the other hand, generally involve

larger numbers of streams of thought from which operationalisable hypotheses can be deduced and tested with quantitative research strategies, thus requiring large samples for inferential statistics.

The triangle reminds doctoral candidates that methodology can only be decided in relation to epistemology and ontology (Tsang, 2016). In other words, it helps doctoral candidates integrate method, theory, and data, with a focus on theory development (original contribution to knowledge) rather than research methods per se (Hillman, 2011). On the other hand, such an integration of method, theory, and data through 15 decisions helps doctoral candidates realise that an empirical research project involves a sample of data, but also of theory and method (Mullins & Kiley, 2010). In terms of academic writing, the triangle provides food for thought for the structuring of the literature review (theory), the methodological section (method), and the discussion of evidence (data) in academic texts such as research proposals, dissertations, and articles.

In addition to the 15 decisions on theory, method, and data, the first author included in the Idea Puzzle framework three decisions on rhetoric, following Van de Ven's (2007) notion of engaged scholarship that is rigorous for academic audiences and relevant for society. The three rhetoric decisions of the Idea Puzzle framework are "pathos", "logos", and "ethos", following Aristotle's trilogy on rhetoric. Such three types of arguments are expected to raise awareness of the emotions, logic, and credibility conveyed by the conclusions of an academic text.

In terms of emotions, it is relevant to consider the academic, public, and commercial interest of the research project as well as its ethical and political implications. In terms of logic, it is important to acknowledge the difference between inductive, hypothetic-deductive, and abductive reasoning. The credibility of an academic text largely results from the disclosure of theoretical, methodological, and empirical limitations. The three rhetoric decisions of the Idea Puzzle framework thus provide inspiration for the conclusions of an academic text, namely in terms of research and practical implications, in spite of theoretical, methodological, and empirical limitations.

The final three decisions of the Idea Puzzle framework are authorial in the sense that the author is conceptualised as part of the system of 21 dilemmatic decisions (McGrath, 1981). In particular, the author's CV and future career is regarded as an accumulation of three interdependent, intangible and irreversible assets – "wisdom", "trust", and "time" – following Pierre Bourdieu's (1986) notions of cultural, social, and economic capital, respectively. Wisdom includes the author's education as well as personal and professional experience which will benefit the research project (Huff, 2009). Trust is a restricted notion of networking, since it only refers to persons that will be mentioned in the acknowledgements of an academic text. Time refers to

the author's availability for the research project since part-time working regimes are usually associated with lower completion rates (Council of Graduate Studies [CGS], 2007).

The overall Idea Puzzle framework of 21 decisions thus emphasises the need for integration of theory (epistemology), method (methodology), and data (ontology) – the triangle mentioned by Parente & Ferro (2016) – as well as rhetoric (axiology of the audience) and authorship (axiology of the author) – upper and lower inner parts of the triangle, respectively – for a coherent research design in the light of Philosophy of Science (Morais, 2010). Such an integrative and holistic view of research design follows previous calls for more integrative thinking in general (Kallio, 2011) and doctoral training in Philosophy of Science in particular (Abrahamson, 2008).

Such a systemic perspective of the research process (Brinberg & McGrath, 1985) based on dilemmatic decisions (McGrath, 1981) complements the chronological visualisation of the research process as a sequence of project tasks such as literature review, data collection, and data analysis (Bryman, 2012). In the terminology of the Vitae Researcher Development Framework (Careers Research and Advisory Centre [CRAC], 2010), the Idea Puzzle framework emphasises the need for problem solving skills for research design (cognitive skills) as a complement to project planning and delivery skills for research planning (research management skills). The following section reviews the development of the Idea Puzzle framework into a software and its application at the University of Auckland.

THE IDEA PUZZLE SOFTWARE AT THE UNIVERSITY OF AUCKLAND

In 2008, the first author established a public limited company – Idea Puzzle – to visually support integrative research design based on Philosophy of Science through a dedicated website and software based on the Idea Puzzle framework. The initial funding included, among others, seed capital from a public limited company – Crivo – that specialises on university spin-offs and individual researchers licensing intellectual property from applied research.

The main research and development expenses of Idea Puzzle are the continuous investment in the Idea Puzzle website and software as well as in free seminars lectured by the first author in HEIs. In 2009, the beta version of the Idea Puzzle software was made available for free at the respective website. In 2012, the University of Porto became the first HEI ever to acquire the license of the Idea Puzzle software, having renewed it annually ever since.

In its current version, the Idea Puzzle software asks 21 questions, helps answer them, and allows the self-evaluation of each answer. The sequence of 21 questions follows a funnel logic to help focusing a research design. The output of the Idea Puzzle software is a research design with an overall score and a visual jigsaw puzzle based on the 21 answers and the respective self-evaluation. The estimated time to complete a research design is of one working day, ideally six months after enrolling in a PhD.

The main benefits of the Idea Puzzle software are the coherent design and defence of a research project from the point of view of Philosophy of Science (Morais, 2010). To date, the Idea Puzzle software has helped design more than 4000 research projects worldwide.

In 2017, the University of Auckland agreed to purchase a university-wide license of the Idea Puzzle software. Since it was not created exclusively for the University of Auckland it was necessary to make it work for its constituencies. This was achieved through: a) communications to supervisors and doctoral candidates; b) a mandatory induction day for new doctoral candidates in the first few months of candidacy; c) the "Writing the full thesis or research proposal" workshop; and d) the "Organizing and writing the literature review" workshop.

In particular, the Idea Puzzle software has been explained to the doctoral candidates and supervisors through university-wide communications, emphasising that it complements rather than replaces regular academic support. After the induction day, participants are sent an email message thanking them for their involvement during the day and mentioning that they can delve more deeply into the question of what doctoral level research is (one of the key discussion themes during the induction) for their own project, by registering at the Idea Puzzle website. In addition, doctoral candidates are advised to watch the 25-minute *YouTube* presentation by the first author to help them understand the software's purpose. This approach ensures that all new doctoral candidates get to know about the Idea Puzzle software and its contextualisation within their doctoral induction to the university.

In addition, two core Doctoral Skills Programme (DSP) workshops have been redesigned – "Writing the full thesis or research proposal" and "Organizing and writing the literature review" – to accommodate the Idea Puzzle software. In particular, each student has to submit a fully developed thesis proposal before final confirmation into the doctoral programme around nine months after enrolment. While the required length and format of the written proposal will vary from faculty to faculty, they all go through independent review by a departmental or school postgraduate committee and each student has to meet with the committee members to discuss and (if required) defend it. And, in essence, all proposals irrespective of academic discipline, need to demonstrate that: there is a coherent thesis question or problem

(that will likely yield an original contribution); the doctoral candidates are aware of the key debates in the literature pertinent to their topic; the methodological approach is appropriate for the task at hand; and that, overall, the document is coherent, well written, scholarly, and persuasive.

With the availability of the Idea Puzzle software to help doctoral candidates think through the key questions about their research (and hopefully spark conversations with their supervisors about ontology and epistemology), the DSP thesis proposal workshop has been altered to focus more on the university's requirements (timelines, resources, financial support for attending academic conferences, and conducing fieldwork etc.) and examining recent thesis proposals donated by doctoral candidates in their second and third years as University of Auckland exemplars. So, the face-to-face workshop deals with the practicalities of producing a written document to meet the university's expectations with the proviso that the Idea Puzzle software is the recommended mechanism to develop the content for their full thesis proposal.

On the other hand, people attending the "Organizing and writing the literature review" workshop are asked to watch the first eight minutes of the 25-minute *YouTube* presentation by the first author, where he overviews the "theory" set of questions embedded in the Idea Puzzle software. The pre-workshop information thus instructs participants as follows:

Dr Morais discusses the literature review: key words, key debates in your research as well as methodology and data collection. His talk is 25 minutes; the opening eight minutes deal with the literature review (the first five theoretical questions of the puzzle). Watch the whole presentation if you have time before the workshop but, if nothing else, please view the first part where he discusses the literature review and think about the questions he poses. We will build on these in the workshop.

This preparation not only directs doctoral candidates to the Idea Puzzle software as a resource for the entirety of the doctorate but in the short-term it helps focus the workshop discussions and activities to a higher level of abstraction rather than getting bogged down in minutiae of each person's literature review. Facilitators ask participants to explain their two key concepts or key search terms in smaller groups and give a lay person's explanation of not only who were (or are) the seminal researchers for their topic, but why these researchers, and their associated works, are important. These conversations are to help participants create a narrative or overarching purpose for their literature review, from which they can start identifying sub-section headings for the review and then start writing.

As a result, DSP organisers now expect doctoral candidates to acquire generic project management skills with DSP workshops (CRAC, 2010), deeper integrative

thinking with the Idea Puzzle software (Abrahamson, 2008; Kallio, 2011), and further feedback from their supervisors and methodology teachers. The Idea Puzzle software thus fills in a gap in the DSP, but it requires an introduction to its purpose in the context of the doctorate. This and other issues are discussed in the following section.

ISSUES, CONTROVERSIES, AND PROBLEMS

Between 2007 and 2017, the first author tested the Idea Puzzle framework in 231 seminars with doctoral candidates, supervisors, and methodological teachers. Such seminars, usually with a duration of one hour, provided face-to-face questions and feedback to the Idea Puzzle framework and were supplemented by an online anonymous feedback questionnaire emailed as a link to the participants after the seminar.

In April 2018, the first author presented the analysis of the first 1004 responses to the online anonymous feedback questionnaire at the 13th Quality in Postgraduate Research Conference in Adelaide, Australia (Morais, 2018). The response rate was 15.5%, from a total of 6487 seminar participants from 71 HEIs in 15 countries: Austria, Belgium, Chile, Denmark, Estonia, Finland, Germany, Lithuania, Portugal, Slovakia, Spain, Sweden, Switzerland, UK, and USA.

The online anonymous feedback questionnaire included eight quantitative closed questions to be rated in a scale of 0 to 10. The average rating per closed question was the following:

1. Achieving the objectives of the seminar – 8.7.
2. Contents of the seminar – 8.8.
3. Suitability of the teaching method – 8.7.
4. Study materials – 8.0.
5. Interaction with the participants – 8.2.
6. Lecturer's knowledge of the topic – 9.5.
7. Clarity of teaching – 9.1.
8. Total evaluation of the seminar and the lecturer – 8.8.

According to such results, the Idea Puzzle framework is primarily associated with new knowledge and clarity. Such feedback may reflect, in turn, the emphasis of the Idea Puzzle framework on Philosophy of Science rather than research methods, on dilemmatic decisions rather than sequential tasks, and on sampling as a matter of data, but also theory and method.

The online anonymous feedback questionnaire also included three qualitative open questions on the best points of the seminar, suggestions for improving the seminar, and topics that could justify other future seminars. The qualitative analysis

of the respective responses generated the following alphabetical index of themes of interest for the participants in the 231 seminars: academic writing, assessment, comparative studies, data analysis, data collection, digitalisation, interdisciplinarity, impact, literature review, Philosophy of Science, project management, Psychology of Science, research cases, research ethics, research focus, research methods, research teams, science communication, Sociology of Science, specialisation, supervision, thesis defence, theory development, and visualisation.

Philosophy of Science was mentioned by 92 respondents as topic that could justify other future seminars (9.1% of the 1004 respondents). Visualisation was mentioned as one of the best points of the annual seminar "How to design your PhD" at the European Institute for Advanced Studies in Management (EIASM) in Brussels: "The Idea Puzzle is very helpful in terms of organising one's research stand and helps visualise the work that is yet to be done."

Based on the facilitation of the 231 seminars and the analysis of the 1004 responses to the online anonymous feedback questionnaire, the first author concluded that:

1. The notion of research design tends to be restricted to method (rather than theory, method, data, rhetoric, and authorship).
2. The notion of sampling tends to be restricted to data (rather than theory, method, and data).
3. Doctoral candidates struggle to find a balance between focus and quality (more theory than they can synthesise, more methods than they can implement, and more data than they can process in the course of a three-year doctorate).
4. Supervisors and methodology teachers tend to convey sequential (e.g., research question first), boundary (e.g., qualitative vs. quantitative) and conflating (e.g., research strategy and technique) myths.
5. Cross-cultural face-to-face seminars are a powerful vehicle for theory development and testing.
6. Online anonymous feedback is more sincere than face-to-face seminars.
7. Online anonymous feedback reveals a wide range of research training gaps from the point of view of doctoral candidates, starting with Philosophy of Science.

In August 2017, the second author conducted a usability testing of the Idea Puzzle software at the Libraries and Learning Services of the University of Auckland, together with a colleague with expertise in digital learning resources. Five international doctoral candidates were individually interviewed while they engaged with the Idea Puzzle software for about 1-2 hours over lunch time. The doctoral candidates were from South and East Asia, South America, and Europe (four of whom were from non-English speaking backgrounds). One interviewee really

liked the Idea Puzzle software and wished it had had the opportunity to use it right after enrolling as a doctoral candidate. Three interviewees were very supportive of the Idea Puzzle software and promptly answered its questions. One interviewee, however, was very ambivalent about the purpose of the Idea Puzzle software in the context of the doctorate.

Navigation feedback from the doctoral candidates included the lack of an explicit conclusion after answering the 21 questions and the impossibility to export the research design in Word format. Deeper feedback included the unclear purpose of the Idea Puzzle software and its integration with the rest of the doctorate.

The DSP coordinators (including the second author), on the other hand, were initially concerned that the four European languages available at the Idea Puzzle website – Portuguese, English, Spanish, and French – would be insufficient for non-European users. Such concerns were partially alleviated, however, when one interviewee demonstrated familiarity with the four languages. The following section presents the solutions implemented to address each of the issues identified in the usability testing at the University of Auckland as well as general recommendations based on the large-scale survey described in this section.

SOLUTIONS AND RECOMMENDATIONS

One of the suggestions of the 19-page usability testing report from the Libraries and Learning Services of the University of Auckland was the creation of an introduction to the Idea Puzzle software at the Idea Puzzle website (Morais & Brailsford, 2018). As a result, a new home page was created ("Introduction to the software"), including a short text and a video introduction.

The introduction states the problem (lack of doctoral training on Philosophy of Science, integrative thinking, timely completion, and focus); the solution (visual decision-making tool for an integrative research design based on Philosophy of Science, including output, examples, benefits, and practicalities); as well as the time and timing required to complete a research design (one working day, ideally six months after enrolling in a PhD).

In terms of usability, the following updates were made in the Idea Puzzle software:

1. The 21 jigsaw pieces of the triangle are now triggered by the user's mouse to pop-up an alternative text stating their category (theoretical, methodological, empirical, rhetorical or authorial) and the respective question.
2. The word implicit was removed from all questions.
3. The help button has now darker and larger font than other buttons.

4. The philosophical terminology was removed, except in the help to answer question 6 (philosophical stance).
5. The examples in the help are now more prominent.
6. The examples now include five disciplines (Design, Engineering, Management, Medicine, and Psychology).
7. The help and examples now open in a new page of the Internet browser to be more visible.
8. A button "previous" has been added before "next", being deactivated in question 1.
9. The button "next" was deactivated in question 21 to prompt users to conclude the process of answering the 21 questions with the buttons "preview" and "print PDF".
10. A button "convert PDF" was added to the software menu to allow the sharing of the research design with supervisors and methodology teachers in Word format.

In terms of recommendations, this section builds on the results of the large-scale survey presented in the previous section to suggest higher plurality of contents in doctoral curriculum (Gonzalez-Ocampo et al., 2015). In particular, doctoral candidates need to be aware of holistic (Huff, 2009) rather than restricted notions of research design (Creswell, 2009) to account for the integration of theory, method, data, rhetoric, and authorship in their research projects. In addition, they might benefit from an extended notion of sampling that applies to data as well as to theory and method (Mullins & Kiley, 2010).

Particularly delicate is the struggle of doctoral candidates to find a balance between focus (McGrath, 1981) and quality (Brinberg & McGrath, 1985). In this respect, this section suggests a period of divergent reading in the first six months after enrolling in a PhD and convergent thinking thereafter. Correspondingly, doctoral candidates are invited to diverge with mind and conceptual maps (Eppler, 2006) in the first six months, and converge with the Idea Puzzle software thereafter (Parente & Ferro, 2016).

A related issue is that doctoral candidates should not be asked by supervisors or methodology teachers a research question or hypothesis as necessarily the first step in research design because it tends to be deduced from the literature review (Bryman, 2012). This is not to say, however, that research is just a sequence of project tasks such as the literature review because it also involves dilemmatic decisions (McGrath, 1981).

In addition, it is important to clearly separate philosophical stances, research strategies, and techniques for data collection and analysis (Creswell, 1998) and to remain open about the pros and cons of qualitative, quantitative, and mixed

research designs (Creswell, 2009; McGrath, 1981). Finally, more research training on Philosophy of Science is needed for doctoral candidates (Abrahamson, 2008) so that a PhD may indeed mean that one has become a Doctor of Philosophy no matter the discipline of graduation. In line with these recommendations, the following section suggests avenues for future research.

FUTURE RESEARCH DIRECTIONS

Although this chapter presents the results of a large-scale survey and a usability testing, further feedback is necessary to validate the impact of the Idea Puzzle software on its users. As a first step in that direction, the online anonymous feedback questionnaire has been updated to include two quantitative and two qualitative questions on the utility and usability of the Idea Puzzle software for the participants in the respective seminar.

In similar fashion, further usability testing such as the one conducted at the University of Auckland is necessary to better understand the contribution of the Idea Puzzle software to the research of doctoral candidates. This is particularly important given the continuous investment on the Idea Puzzle website and software as a result of user feedback and technological development.

By the end of 2018, approximately 630 new University of Auckland doctoral candidates will have been exposed to the Idea Puzzle software through the induction day. The two authors will then be able to calculate the proportion of new candidates who voluntarily took up the offer to register at the Idea Puzzle website. In addition, it will be possible, with ethics approval, to invite users to attend focus groups that explore how they used the Idea Puzzle software, especially to develop their full thesis proposal and write a draft literature review chapter.

Another avenue for future research is the study of the Idea Puzzle software as a knowledge visualisation tool. In this respect, it will be important to assess possibilities such as different colours or shades to further clarify its three levels of synthesis: a) three sides of the triangle; b) five categories of decisions; and c) 21 key decisions. A related issue is whether the jigsaw puzzle metaphor employed by the Idea Puzzle software may be complemented with other mapping methods (Eppler, 2006).

These questions provide interesting avenues for future research. In particular, it will be important to conduct both qualitative and quantitative studies of users' reaction to the Idea Puzzle software in the context of their doctorate. More importantly, it will be relevant to assess if the use of the Idea Puzzle software increases completion rates above their institutional average.

CONCLUSION

The Idea Puzzle software stimulates visual integrative thinking (Kallio, 2011) for coherent research design in the light of Philosophy of Science (Morais, 2010). In particular, it provides a framework of three domains (Brinberg & McGrath, 1985), five major categories (Epper, 2006), and 21 dilemmatic decisions (McGrath, 1981) for a more holistic (Huff, 2009) and visual (Meyer et al., 2013) integration of research design. For that purpose, it employs a visual metaphor which is known for its cognitive and instructional virtues as well as for its adoption by several philosophers of science (Eppler, 2003). The particular visual metaphor of the Idea Puzzle software is the jigsaw puzzle, a human-made object which was invented for educational purposes (Hannas, 1972). A large-scale survey in 71 HEIs based on an online anonymous feedback questionnaire following 231 seminars in 15 countries inspired recommendations for doctoral education. In particular, the adoption of the Idea Puzzle software in HEIs suggests the need for more Philosophy of Science and Knowledge Visualisation in doctoral curriculum (Gonzalez-Ocampo et al., 2015). In addition, the first usability testing of the Idea Puzzle software at the University of Auckland allowed the identification of issues and respective solutions concerning its utility and usability. Correspondingly, the main suggestions for future research are the need for more studies on the utility and usability of the Idea Puzzle software as a knowledge visualisation tool for the overall design of a research project.

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KEY TERMS AND DEFINITIONS

Conceptual Framework: An analytical tool that depicts a certain phenomenon parsimoniously.

Integrative Thinking: A synthesis of lower-level elements that integrates and reformulates them into a coherent new whole.

Jigsaw Puzzle: A human-made object with the educational purpose of assembling jigsaw pieces with different shapes to convey an overall picture.

Knowledge Visualization: A visual representation that allows the transfer and creation of knowledge between two or more persons.

Philosophy of Science: An academic discipline that studies the logic of scientific discovery and justification for the acquisition of original knowledge.

Research Design: A draft that integrates theory, method, data, rhetoric, and authorship for subsequent implementation of academic research.

Research Software: A computer-based application that converts inputs into outputs to support the user in one or more research tasks.

Usability Testing: A face-to-face session in which interviewers register the reactions of interviewees as they interact with a certain website or software.

Visual Metaphor: A visual representation that maps knowledge with the support of an analogy from the natural or human-made world.

Visual Representation: A mode of communication based on holistic and immediate visuals rather than linear and sequential verbalization.