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Main Article:

Influence of Personal Epistemology on Research Design: Implications for Research Education

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Abstract

This study was aimed at determining whether a specific research methodology was dominant within a cohort of master's level engineering management students and, if so, whether this preference was directed by their personal epistemology, rather than the dictates of their research questions. Secondary data were used to determine the dominant research approaches. Interviews with a selected sample of students were undertaken to obtain a more detailed understanding of how personal epistemology impacts on the students' methodological approaches to research. It was found that empirical-analytical approaches account for 72% of all studies within the student cohort, indicating a strong preference for such approaches. Furthermore, it was revealed in the interviews that the students tended to overlook methodological considerations, focussing only on research design. There was a general lack of self-reflection and awareness of personal epistemology, despite the latter being an important influence over the type and topic of the research, its purpose, research design, analytical techniques, and even the interpretation of results. The rather superficial approach could result in research designs biased by personal epistemologies and ill-suited to the research problems. This suggests possible changes to the teaching of research methodology in order to improve the research practice of students.

Index Terms: engineering management; master's dissertation; personal epistemology; realist epistemology; relativist epistemology; interpretative phenomenological analysis; research methodology course; research design; research education

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1. Introduction

An important objective of any university course on research methodology is to introduce students to theories of knowledge, thereby facilitating a deeper and more self-reflective understanding of their own beliefs, and potentially leading to higher-quality research outcomes. A student's beliefs concerning epistemology, covering how s/he conceives of, relates to, and understands knowledge, is known as *personal epistemology* (Hofer, 2000; Hofer & Pintrich, 1997). These beliefs are active in, constitutive of, and influence the way in which we learn and work (Billett, 2009).

Using this concept, the goal of a course in research methodology can be described as an attempt to address the incomplete assumptions of personal epistemologies, thereby improving the practice of research. A failure to acknowledge and reflect on these assumptions could lead to methodological bias, arising from an underlying misunderstanding of the qualities of knowledge and its link to data and the research context. The influence of personal epistemology on the learning and achievement of students has been well documented (Brownlee, Walker, Lennox, Exley, & Pearce, 2009). There have also been studies of how personal epistemology varies within faculty members and affects pedagogy (Lederman, 1992; Montfort, Brown, & Shinew, 2014). However there has been limited research on the success of research methodology courses in supporting the self-awareness of a student's personal epistemology, and particularly in postgraduate engineering students, who are mostly unfamiliar with research practice.

The broad question explored in this article is whether and how the personal epistemologies of engineering management students affect the way in which they undertake research (Hofer, 2000). Our understanding of engineering management should be improved if researchers were to be more aware of, and receptive to, a wider range of research designs, particularly those informed by the perspectives of relativism and interpretivism (Edmondson & McManus, 2007). The following specific research questions were addressed in the study:

1. What research approaches were used by a cohort of engineering management students over the period 2013 to 2015?
2. Were the researchers aware of their personal epistemology during the critical conceptual and analytical periods of their research projects?
3. Did personal epistemology influence their research design? If so, how?

2. Background Literature

Selected literature on research process, epistemology, and epistemological development of research students has been reviewed as relevant to the discussion.

2.1. Research, Knowledge and Epistemology

There are multiple definitions of research, many of which share three core dimensions. First, research is a process or activity; second, its purpose is the generation of new knowledge (Kothari, 2004); and third, it conforms, or should conform, with specific

quality requirements for knowledge, including the requirements implied by the labels "scientific" and "objective" (Marais, 2012; Welman, Kruger, & Mitchell, 2006). Marais (2012) describes these as the constituent components (process), epistemic criteria (knowledge quality), and teleological function (purpose) of research. The constituent components include "linguistic and para-linguistic representations of phenomena (words, concepts, constructs, symbols of all types)," "questions about phenomena (conjectures, theses, hypotheses)," "observation of phenomena (sensory perception, experience, measurement)," and "communication of what has been observed (general discussions, news reports, scholarly publications)" (Marais, 2012, p. 67).

In this article, we have adopted a definition of research based on the above three core dimensions. We also note that the dimensions are linked to research design, which is shaped by the principles of research methodology. We define research methodology as the body of methods and principles which form the basis of research, including the description and explanation of research designs. It covers the study of the various steps followed by a researcher in tackling a research problem together with the associated logic. Our definition is consistent with the literature but different from the widespread use of the term as referring, perhaps pretentiously, to the research methods of a single study. The latter we refer to as the research approach; examples include interpretive-hermeneutic, empirical-analytical, and mixed-methods approaches.

Given that research is an activity leading, mainly, to the generation of new knowledge, and that epistemology considers the nature, limits, and justification of human knowledge (Hofer & Pintrich, 2004), it is clear that an understanding of epistemology is pertinent to undertaking research. In this sense, research, epistemology, and knowledge are interconnected.

Knowledge has certain prerequisites for it to be possessed by a person. First, knowledge is formulated and, to a large extent, exists in the mind. Second, in order for knowledge to exist, a person must have a belief about it. A belief, therefore, is a prerequisite for, but not equivalent to, knowledge. The relative importance of meaning or belief in the construction of knowledge is, however, contested, with opposing perspectives such as those by relativists and realists.

Relativists postulate that knowledge is based primarily on meaning and is specific to a particular individual, group, or society, being largely shaped by how they interpret or understand it. The realists postulate that there is an "objective truth" which exists outside of the observer (Hofer & Pintrich, 2004). This implies that if one has a belief about a phenomenon and this belief does not match an objective truth, then this belief does not constitute knowledge.

Such questions about the authenticity of knowledge are being asked continuously by epistemologists, with one solution being to adopt domain-specific definitions. Although epistemology in general has been extensively studied (Perry, 1968), more recent attention has gone to discipline-specific issues. Researchers are concluding that epistemology may not be consistent across disciplines and that discipline-specific epistemic beliefs should be considered (Greene, Azevedo, & Torney-Purta, 2008). In this study, a specific discipline, namely engineering management, has been considered.

2.2. Personal Epistemology

Personal epistemology reflects how an individual's belief impacts on cognitive processes including how s/he thinks and reasons. An example offered by Hofer and Pintrich (2004, p. 3) explains that students receiving the same instruction in a classroom may view knowledge differently. On the one hand, they may consider it to be a "set of accumulated facts," on the other hand, they may view it as "an integrated set of constructs." In this respect, they may view themselves as "passive receptors" or "active constructors" of knowledge.

According to Covey (2004), we view and interpret the world through the paradigms which we construct ourselves. A similar perspective applies to research, where our principles in terms of knowledge and learning should be understood and acknowledged by researchers in order to ensure the integrity and validity of research are not compromised (Moon & Blackman, 2014). Researchers with an understanding of their ontological, epistemological, and phenomenological positions will be able to account for their own subjectivity in their research designs and conclusions.

The development of individual belief systems is therefore fundamental to research. It is the means by which observation of a physical or non-physical reality is translated through rationality into "truth claims." Moon and Blackman (2014) portrayed this relationship between reality, mind, and knowledge as being variously constructed depending on the observer's personal epistemology. For instance, objectivists would consider a single reality which is independent of the observer, whose task is then to develop knowledge based on the observation of that reality. On the other hand, constructivists would believe that meaning is derived from the researcher's construction of reality, and we should both acknowledge and respect the subjectivity of the process through which observations are translated to knowledge.

Personal epistemologies of individuals within specific disciplines may represent different belief systems that have evolved within different contexts. These belief systems are applied when researchers tackle abstract epistemic questions, such as the nature of knowledge, how to justify knowledge, and where to source knowledge, with the latter changing from external sources such as authority figures to internally constructed knowledge via interaction and collaboration (Hofer & Pintrich, 2004). Variations in personal epistemology can result in researchers using either an *interpretive-hermeneutic* or an *empirical-analytical* approach to address the same set of research questions. Our argument is not that these differences are necessarily a concern, nor that they reflect different levels of educational achievement. However, it becomes a concern if the resulting choice of research method differs from what is suggested by the nature of the research questions. It is argued here that researchers should be conscious of, and in some cases distance themselves from, their personal epistemological biases.

The evolution or progression of belief systems as a consequence of education has been a subject of study. In one study, Perry (1970) conducted a series of interviews among Harvard College students and developed a framework to cover this progression. The scheme consisted of nine stages, beginning with a dualistic conception of knowledge

(true/false), and leading to a relativist approach in which knowledge is highly contextual and located in individualised paradigms or epistemologies.

In this research, we have not applied Perry's framework and its implication that a transition from dualism to relativism represents a progression to a higher level of thinking (Zhu & Cox, 2015). Within our context, it is apparent that some research questions can be suitably approached through a relativist epistemology whereas others can be better approached using a realist or objectivist epistemology. In our opinion, the hierarchical structure of Perry's framework is itself a reflection of bias and its use could induce a judgement of student choices with respect to research method. The latter may not be necessarily linked to a student's level of education.

In summary, research is an activity leading to the production of knowledge, where the latter must conform to an acknowledged set of epistemic criteria (Marais, 2012). The activity, and hence its outcome, can be influenced by the researcher's personal epistemology, which is itself dynamic. Therefore, the researcher's awareness of his/her personal epistemology is important. The goal of any course in research methodology is to create this awareness and, where necessary, to minimise any negative influence on the research. Failure to do so would amount to the researcher engaging in self-fulfilling prophecy rather than producing new knowledge.

3. Research Design

3.1. General Approach

We followed the general approach of interpretive-hermeneutics as we considered it most effective in attempting to access the individual researchers' experiences and the underlying meaning of their decisions (Hathaway, 1995) in trying to understand epistemology and methodology within the context of their own projects. According to Maree (2007), interpretive-hermeneutic research involves a focus on how individuals view and understand the world, and how they construct meaning out of their experiences, by attempting to observe the world through their eyes. Interpretive-hermeneutic research involves understanding the processes which underlie various behavioural patterns (Maree, 2007), making it appropriate to enquire into the epistemological positions of the participants and how their individual research approaches/designs are affected by these positions.

At a more detailed level, the project used interpretive phenomenological analysis (IPA) as the basis for its research design. Phenomenology can be defined as "an approach that describes the actual way we experience the world and ourselves, but without fitting the phenomenon of our experiences into preconceived patterns of interpretation" (Fabry, 1980, p. 27). The philosopher Martin Heidegger had a view that the "being" or meaning of a phenomenon should be investigated rather than the phenomenon itself. He stated that all understanding in any field of knowledge is an interpretation (Converse, 2012), and that a study of the interpretation is precisely what develops meaning.

IPA is one form of phenomenological enquiry and is essentially an interpretive-hermeneutic approach. It involves the use of discussion and the sharing of meaning in the research process. Smythe et al. explain the method in the following way:

> As researchers . . . we are never outside our research, never planning ahead with full confidence that we know precisely how it will be; rather we are always already in the midst of the research, confronting the possibilities, making choices, wrestling with the restlessness of possibilities. (Smythe, Ironside, Sims, Swenson, & Spence, 2008, p. 1391)

IPA is a method to develop meaning which is not explicit but is revealed only through a detailed study and interpretation of text (Smith, 2007). It allows the researcher to capture the beliefs, constructs, and meanings from the participants' talk.

3.2. Sampling Strategy

This study was set at the Graduate School of Technology Management, University of Pretoria, South Africa. Data for the first research question (on the research approaches used by engineering management students) were extracted from all the dissertations submitted over 3 years (2013 to 2015) for the Master of Engineering degree.

The sample for the second and third research questions (on personal epistemology and research design) was drawn from the current students. The sampling criteria required students to have completed the first four chapters of their dissertations and to have served in industry as an engineer for a minimum of 3 years (this is the length of experience required by the Engineering Council of South Africa for registration as a professional engineer and the typical length of graduate development programs in industry). Within this cohort of students, a purposive sampling strategy was followed in order to ensure that the full diversity of the different research approaches was included (both interpretive-hermeneutic and empirical-analytical studies). A total of 6 students were interviewed and the conversations were recorded. The relatively small sample size allowed for a more in-depth probing of the participants' beliefs and assumptions about research.

It is noted that all students in this cohort followed a similar process in undertaking their research. The process consists of an initial module on research methodology (Phase 1), followed by an 18-month period in which students incrementally complete the various segments of their mini-dissertations, such as literature review, definition of the conceptual model, research design, and ethics application (Phase 2). The finalisation of the research proposal takes place during Phase 1 under the guidance of a research committee with expertise on the relevant knowledge domains within engineering management. The students are permitted to develop their own topics or select a topic from a list proposed by the academic staff and research supervisors associated with the Graduate School.

Given the complexity of general discourse on research methodology and the diversity of research designs, it is challenging for any course presenter to sufficiently cover the background material and ensure that each student is well prepared for Phase 2. The research presented in this article relates to this issue, namely the extent to which Phase 1

is able to guide students and ensure high-quality research outputs. Although we studied a single cohort, this issue is common to the preparation of all researchers and the insights from the cohort should be useful within the broader community of research educators.

3.3. Data Analysis and Interpretation

The first research question was answered using descriptive statistics only. Dissertations submitted over the 3 years (2013-2015) were categorised in terms of the knowledge area, research design, and data gathering method. The different research designs were then summarised and expressed as a percentage of the total number of dissertations.

As already stated, IPA was used to answer the second and third research questions. The technique required the researcher to play a central role in understanding and interpreting the personal experiences of the participants (Pringle, Drummond, McLafferty, & Hendry, 2011). Conversations between the researcher and the interviewees flowed in a semi-structured manner, in which only the final destination was dictated by the research questions, but the path leading to this destination emerged during the conversation.

Interview data are typically analysed by finding themes that repeat throughout the data. These themes are then analysed to produce the conclusions of the research. A more refined understanding of this process, as proposed by Van Manen (1990), was followed in this study:

> grasping and formulating a thematic understanding is not a rule-bound process but a free act of 'seeing' meaning. What we call 'themes' are not necessarily 'the same thing' said again and again, but rather an understanding that we have seen something that matters significantly, something that we wish to point the reader towards. (Van Manen, 1990, cited in Smythe et al., 2008, p. 1392)

3.4. Quality Assurance

Interpretive-hermeneutic research studies, especially those applying a phenomenological strategy of enquiry, require creativity, which can be seen as threatening the validity of the research. On the other hand, a structured, systematic application of methods will result in what Whittemore et al. describe as a "potential procedural charade" (Whittemore, Chase, & Mandle, 2001, p. 526). This research aimed to be as creative and exploratory as possible whilst striving to satisfy interpretivist quality criteria in order to ensure that representation of the participants' personal epistemologies was authentic.

Conscious attention was paid to the meanings that arose to produce a trustworthy and credible analysis that incorporated but was not dominated by the researcher's subjectivity. The analysis was conducted with the intention of establishing an authentic interpretation of the participants' personal epistemologies. The analysis and interpretation were conducted with the subjectivity of the researcher included as is done in phenomenological studies; however, integrity, dependability, and confirmability were maintained as far as possible by ensuring that the analysis and interpretation were data

grounded, and by cross-checking the main insights of the analysis with the study supervisor.

4. Results

4.1. Quality Assurance

Table 1 shows a summary of the data gathered from the master's dissertations. The titles of the research and names of the authors and supervisors were removed. The analysis of the knowledge areas, where the latter were grouped into broader categories as explained in the notes to Table 1, provided information on the types of problem engineering management research students are aiming to solve and, as a result, whether they may be restricting themselves to certain research approaches.

The research approaches were deducted from the initial chapters presenting the conceptual model and research methodology. The approaches were often not explicitly discussed in the dissertations and, in many cases, an understanding of the wider scope of the research itself was required in order to gauge the philosophical underpinnings of the research, including an assessment of the research designs, data gathering methods and analysis, and description of the results.

Seventy-four dissertations, covering 23 knowledge areas were analysed. The empirical-analytical approach was dominant in the following knowledge areas: Business Processes (86%), Technology & Innovation Management (85%), and Business Strategy (69%). People Management was the only knowledge area in which an interpretive-hermeneutic approach was preferred (71% of the total studies), although this knowledge area contributed only 19% of the total number of student dissertations.

It is noteworthy that, in general, an empirical-analytical approach was dominant in the students' work, with the data in Table 1 indicating an overall preference of 72% (vs. 28%) for this option.

Table 1. *Summary of Research Approaches According to Knowledge Area*

Knowledge Area (KA)	Empirical-Analytical		Interpretive-Hermeneutic		Total	
	Number of Dissertations	Proportion of KA	Number of Dissertations	Proportion of KA	Number of Dissertations	Proportion of KA
Technology & Innovation Management[a]	22	85%	4	15%	26	35%
Business Strategy[b]	9	69%	4	31%	13	18%
People Management[c]	4	29%	10	71%	14	19%
Business Processes[d]	18	86%	3	14%	21	28%
Total	**53**	**72%**	**21**	**28%**	**74**	**100%**

Notes.
(a) Includes science policy, innovation management, knowledge management, manufacturing, research management, and technology management.
(b) Includes configuration management, financial management, lean engineering, marketing management, organisational strategy, systems engineering, and theory of constraints.
(c) Includes human resources, organisational behaviour, organisational culture, people management, social development, and talent management.
(d) Includes maintenance management, project management, safety and environment, and risk management.

Another interesting pattern observed during the analysis was the inappropriate use of quantitative data analysis in studies involving triangulation. An interpretive-hermeneutic research design is typically focussed on depth, whereas empirical-analytical designs are concerned with breadth (Olsen, 2004). However, it was observed that approximately 30% of the dissertations included triangulation, and all but two employed quantitative data analysis using limited sample sizes (sample of 4 to 6).

This observation indicates that the student researchers may have had particular epistemic stances which affected the quality of their work as they attempted to use quantitative data analysis to achieve triangulation in largely interpretive-hermeneutic studies. In these dissertations, there seemed to be inadequate reflection of the methodological tenet, "different methods shine under different lights," as argued by Lamont and Swidler:

> The lessons to be learned from the wave of methodological exchanges that the post-millennium decade has brought us are many. One is that different methods shine under different lights and that one should choose the most appropriate data collection technique based on the question being asked and the types of facts and theories one wants to operate with. Another is that substantive innovation often emerges from a fearless orientation toward mixing methods and research genres so as to develop a multidimensional understanding of social phenomena. Going down a well established path has rarely been conducive to major intellectual innovation. (Lamont & Swidler, 2014, p. 166)

4.2. Interpretive Phenomenological Analysis

Table 2 presents a summary of the participant's responses to question on personal epistemology and research design. Quotations or summaries provided in the table offer an impression of the participants' stances. Each discussion with the participants was unique. Various points of interest arose during the interviews, which were then used to explore the participants' perspectives on epistemology, including their awareness of personal epistemology and its influence on their research approach. More detailed descriptions of the results are presented below the table.

Table 2. *Summary of Participants' Responses*

Focus of Interview Question	**Participant**					
	1	**2**	**3**	**4**	**5**	**6**
Nature of Knowledge	proven with "numbers"	"researching other people's work"	from "experience"	from "experience" and "know-how"	"becoming more aware of a topic"	"gained in general in your day-to-day activities"
Meaning of Scientific Research	conducted with experiments; minimal qualitative aspects	"contributes into the field of science"	"all research is actually scientific research"	"need to prove with physical results"	is more "specific" less "open to interpreta-tion"	"based on facts and figures . . . has more of a right and wrong answer"
Research Design	qualitative data translated into quantitative data	unsure	quantitative in order to "restrict" data for "comparative purposes"	"prefer more quantitative things than qualitative"	more familiar with quantitative but used qualitative	qualitative design: "it helps me understand better where the subject is coming from"
Methodological Approach	described research design	"methods" and "channels" used	prefers empirical-analytical design to compare "apples with apples"	depends on the research	unconvinced if data associated with constructivist research approach is "relevant"	"how you wanna go and structure you research"
Definition of Epistemology	"it's on a higher level"	"centre of research"; "root of positivist, constructivist, qualitative, quantitative"	"generation of new knowledge"	"depends or your research," but not in this case because "I'm more based on facts"	no definition or relation to research provided	no definition or relation to research provided
Nature of Truth	proven with "physical experiments"	"supported by other researchers"	"set to be a true by society"	"more about the quantity of people"	"things that are scientific"; "not numerical necessarily but like some form of factual base"	"it depends on the perspective from which you look at it"
Truth and Relativism	n/a	n/a	"a fact is, I would say, relative"; "being relative . . . it isn't necessarily true"	facts need to be "proven" "through an experiment"	n/a	"it's all from the perspective that you look at it"

Focus of Interview Question	Participant					
	1	2	3	4	5	6
Researcher Bias	"should be prevented as much as possible"	depends on the research	researcher must not influence the research	researcher needs to interpret to account for inaccuracies supplied by participants	"it's going to be tricky"; "you are biased whether you know it or not"	"I will in some way or another . . . I'm gonna put my own spin on what I gather"
Epistemic Validity	"facts" obtained rather than "feelings"	"need to stuff it with facts"	people with experience and credentials can be trusted	depends on the "quantity of people"	"validated by some form"; "validated by other people as well"	"it just takes one person to see it from a different point of view that could be right"
Significance of the Research	related to work	"made practically more sense"	related to work	"there's a project that I know that we get data from"	"it is something that I actually like, I'm interested in"	"it had a personal meaning to me"

4.2.1. Nature of Knowledge

Participants were asked to discuss what they believed knowledge is, where it comes from, and the differences between empirical and non-empirical knowledge. Most participants said that experience is a large contributor to gaining knowledge. Participant 1 said that the most accurate type of knowledge is knowledge that can be proven with "numbers." They had slightly different opinions as to the source of knowledge. Some indicated that it is obtained from experience; one participant said it comes from research and another said it comes from your day-to-day activities.

It was apparent that the participants had different views on knowledge and this may have had an effect on how they conducted their research. For example, since Participant 1 believed that the most valid form of knowledge is one that can be proven with numbers, it is possible that this would have influenced the participant's decision to conduct a quantitative study. This researcher might insist on an empirical-analytical approach to a study requiring an interpretive-hermeneutic outlook, for example, a study of human behaviour, meanings, or relationships.

4.2.2. Purpose of Research

The participants seemed to have a common understanding of the purpose of research. They indicated that research broadens our knowledge in a particular field. They said research also builds on previous work, builds a knowledge base, and it is the first attempt to understand something better. The participants thus indicated a link between knowledge and research.

4.2.3. Meaning of Scientific Research

Many associated scientific research with empirical-analytical and quantitative approaches. Those that applied qualitative or hermeneutic-interpretivist approaches did not believe that their own research could be classified as scientific. They did not think that different approaches could be used to achieve scientific results as long as a suitable research process is followed and relevant quality criteria are fulfilled.

4.2.4. Research Design

Our analysis of the past dissertations showed that most of the previous students, when describing their research approaches, placed more focus on the details of their research designs, as opposed to their overall approach. It was found that the participants did confuse research design with methodology. In their attempts to explain research methodology, they mentioned qualitative and quantitative data, research tools, and research methods. None of the participants associated research methodology with any kind of philosophical framework. The concepts of positivism and constructivism were then discussed with the participants, and they were asked if they would be comfortable with both. Participant 3 said that analysing qualitative data would prove to be difficult since there is a need to compare "apples with apples." Participant 2 said that positivist approaches are associated with "facts": "I guess positivist. I mean, like I said I like to focus my stuff on facts . . ." This indicates that these participants may not have much faith in, and are thus less likely to apply, other approaches.

4.2.5. Definition of Epistemology

It was assumed in this study that being able to define the term *epistemology* is a proxy indicator for the awareness of engineering management students of their personal epistemologies. If there is a lack of understanding of the concept in general, it is less likely that such students will have an understanding of personal epistemology.

It was observed that only Participants 2 and 3 were able to give an indication as to the definition of epistemology. The other participants tried to recall the concept from a previous course on research methodology but were unable to do so. In general, it was concluded that there was insufficient understanding of personal epistemology to inform a balanced discussion on methodological approaches, as is required for students at master's level who are undertaking research projects.

4.2.6. Nature of Truth

What we believe constitutes fact or truth is an indication of our epistemic beliefs. If the participants were aware of their personal epistemic beliefs and if these were considered in their research, the participants should be able to explain their stances on the concepts of fact and truth. This was not the case during the discussions.

Participant 1 did have a clear answer. The participant said that facts need to be proven with "physical experiments" or by "a lot of analysis of data." This seems to point towards a realist personal epistemic view and it can be seen how this has filtered down into the

participant's research design (and methodology). Participant 1 explained that qualitative data would be acquired, translated into a quantitative format, and then analysed. Looking back at the participant's view on what constitutes fact, the participant is not doing any physical experimentation but the participant will be doing "a lot of analysis of data." Therefore, given the participant's personal epistemic view, the participant is likely to classify the research as "factual" and "scientific."

Participants 2, 3, and 4 all associated facts with the amount of people that make the same claim. They suggested that a fact is "supported by other researchers"; it is something that is accepted by society as being true.

Participant 5 seemed to display a realist personal epistemology. Participant 5 also suggested that being an engineer has an influence on one's epistemic thinking. According to participant 5, facts are "things that are scientific or things that have some uhm, like not numerical necessarily but like some form of factual base." In contrast, Participant 6 seemed to display a much more relativist personal epistemology: "it depends on the perspective from which you look at it" and "I'll produce a document that might not be correct; it will still have my bias, but to me it's the best information that I have, to me it's correct." The idea that facts are determined relative to specific people or groups is a relativist idea. Participant 6 claimed that each person puts their own "spin on it" and looks at it from a different "perspective."

4.2.7. Truth and Relativism

Some of the participants indicated that a truth or fact can be defined by what society or a group of people believed to be true. Other participants indicated that something can be proven as a fact by physical experimentation. In response to these perspectives, the example of the shape of the earth was then presented. In this case, what we consider as a truth (that the earth is an oblate spheroid) is different from the truth that some previously believed (that the earth is flat). This new truth has also begun to change over the past few years to a "mathematically true" shape of the earth (Daily Galaxy, 2011). The example was used in order to challenge the participants' view of truth and to probe their thinking.

Participant 6 appeared to take a balanced, critical realist perspective, acknowledging that there may be a truth but "it depends on the perspective from which you look at it." Other participants were more committed to the idea of an absolute truth, verified by society.

4.2.8. Researcher Bias

Participant 1 said that the researcher should "be as neutral as possible." The participant expressed that the researcher should be kept separate from the study especially with regard to the researcher's experiences and opinions: "they shouldn't say like 'okay', 'based on my experience' or things like that, where you bring your personal experience, your personal opinion into it; that should be prevented as much as possible." Participant 2 said that it depends on the research that is being conducted. Participant 3 was in agreement with Participant 1: "I think the uh, interviewer must not state his opinion, because that will then or there is a possibility then that his comments will influence the respondent."

Participant 5 believed that separating the researcher from the research is more difficult than the other participants seemed to suggest: "I think it's going to be tricky to like separate my interpretation of stuff from the people's things that I'm getting, because I'm interpreting my own self in the whole thing." Participant 5 said that ideally the researcher should be separated from the research however, "you are biased whether you know it or not."

5. Discussion

This study found that there was a lack of awareness of personal epistemology within the sample of student researchers. Few participants reported any conscious decisions regarding their research approaches as a consequence of a detailed assessment of their research questions, which in turn affected all decisions downstream. This is not an unusual result; indeed, it is frequently evident that researchers tend to ignore the philosophical foundations of their research thinking, focusing instead on the less abstract question of research design (Hussain, Elyas, & Nasseef, 2013).

A confusion between research methodology and research design was apparent. The participants generally described research design when asked about research methodology, and in their attempt to explain the latter, they focused on research tools, data gathering, data analysis methods, and so forth. All of these relate to the practical steps they might follow in the implementation of their projects, rather than understanding why these steps could be appropriate for their study. This has implications for the teaching of research methodology.

An influence of the participant's personal epistemologies was discerned from the interviews. Participants' personal epistemologies were categorised based on the discussions of various scenarios to gauge their epistemic thinking, including their views on knowledge, facts, truth, and how they apply these in their everyday lives. Their decisions on research approach and research design, and the impact of their supervisors on such decisions, were also discussed. Table 3 shows the participant's personal epistemologies and their research designs.

Table 3. *Personal Epistemology vs Research Approaches*

Participant	Personal Epistemology		Research Approach	
	Realist	Relativist	Empirical-Analytical	Interpretive-Hermeneutic
Participant 1	•		•	
Participant 2		•		•
Participant 3	•		•	
Participant 4	•		•	
Participant 5		•		•
Participant 6		•		•

It is apparent from Table 3 that the participants' research approaches have been chosen based on their epistemological preferences. If there was more awareness of this among the students, they would be more open to other types of studies. As shown in Table 1, researchers in this field have a preference for an empirical-analytical approach. This result is supported by the study of Sułkowski (2015) which indicated that management researchers tend to focus their research mainly on pragmatic considerations as opposed to building on theory

In some respects, it can be argued that the results of this work support Perry's framework and its subsequent adaptations. The general lack of awareness can be interpreted as an educational failure in the preparation of the students for their research projects. Although each student is required to complete a module on research methodology, the preparatory module has limited impact on their educational development. Concepts such as relativism and realism, constructivism and positivism, remain poorly understood and hardly described within the final dissertations.

The results suggest some improvement to the research methodology module in order to improve students' understanding of the core concepts. It has been shown that personal epistemology remains inadequately developed in the preparatory module and, as a result, the students' choice of methodology remains vulnerable to personal bias over what constitutes valid knowledge.

It is possible that such a bias may exist more broadly within master's level students who are attempting their first research projects. For instance, a similar study on the choice of research approach within the area of engineering education supports our perspective. The study concluded that personal experiences unduly influence choice of research methodology despite the argument that this choice should be determined by the research questions (Borrego, Douglas, & Amelink, 2009).

6. Conclusions

These results indicate a need to improve the teaching of research methodology, such that students become more aware of their personal epistemologies and how personal epistemology might impact on their decision on research topics and research design. Although the choice of methodological approach within this cohort is guided and sometimes determined by the supervisor, the students are expected to work independently and make their own decisions, especially when researching topics of their own choice. In such cases, a thorough awareness of personal epistemology is not just recommended, it is essential.

It is recommended that the teaching of research methodology should allow more time for students to reflect on their philosophical assumptions when conceptualising their research studies, including important questions such as these: What is knowledge? What is a fact? On what basis will anyone trust or believe in my research results? How will my interpretation of the results influence the validity of the study? When these questions were posed to the participants, they struggled to find an answer.

Lack of awareness of personal epistemology can be a weakness in research practice. Although this study is based on a small sample of master's level students, the analytical framework and discussion themes have wide applicability. The results may be of value to research educators in assessing whether the core objectives of a research methodology course have been realised.

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