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Mohsen Tavakol & John Sandars

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AMEE GUIDE

Quantitative and qualitative methods in medical education research: AMEE Guide No 90: Part I

MOHSEN TAVAKOL[1] & JOHN SANDARS[2]
[1]The University of Nottingham, UK, [2]The University of Leeds, UK

Abstract

Medical educators need to understand and conduct medical education research in order to make informed decisions based on the best evidence, rather than rely on their own hunches. The purpose of this Guide is to provide medical educators, especially those who are new to medical education research, with a basic understanding of how quantitative and qualitative methods contribute to the medical education evidence base through their different inquiry approaches and also how to select the most appropriate inquiry approach to answer their research questions.

Introduction

Over the past few decades, major advances have occurred in both the understanding and practice of medical education. Medical education research has contributed considerably to these advances by adding reliable new knowledge to an existing body of educational knowledge to produce 'best evidence' that can help medical educators to make better decisions about important areas of medical education, such as teaching and learning, effective curriculum design and assessment. Through research, data can be collected and analysed to better understand the teaching and learning process (Norman 2002) and also to inform decision making about how well a particular programme, practice, procedure or policy is operating (Tavakol & Gruppen 2010). However, there is often little interest by clinicians in medical education research, possibly as a result of a lack of training in education research methods, and with many clinical educators also feeling less confident in the application of qualitative research approaches (Tavakol et al. 2008). This could be due to the fact that the nature of qualitative studies in comparison with quantitative methods has not been recognised (Morse 2005), especially since medical educators tend to gather empirical data that are grounded in objective rather than subjective reality (Buckley 1998). However, the contribution of qualitative studies in evidence-based practice has increasingly been recognised in both healthcare systems and educational research (McEwan et al. 2004; Ong & Richardson 2006; Bower & Scambler 2007).

The purpose of this Guide is to provide medical educators, especially those who are new to medical education research, with a basic understanding of how quantitative and qualitative methods contribute to the medical education evidence base through their different inquiry approaches. It also provides readers with the primary steps of the research process and an understanding of how to select the most appropriate inquiry approach to answer their research questions

Practice points

- Quantitative and qualitative studies are not contradictory, but complementary. Both develop new knowledge for solving research problems.
- Quantitative research has a positivist paradigm, in which the world to be researched is viewed as an objective reality, but qualitative research has a naturalistic paradigm, in which the world to be researched is viewed as a socially constructed subjective reality.
- Qualitative research provides an opportunity to generate and explain models and theories inductively, whereas quantitative research provides an opportunity to test theories deductively.
- When there is little knowledge about the phenomenon of interest, qualitative approaches are suggested to explore and understand the phenomenon.
- In quantitative research, the accuracy of the research results depends on the validity and reliability of the measurement tools, whereas in qualitative research the trustworthiness of the research findings heavily relies on the researcher as a tool, and hence participants should verify their findings.
- Quantitative researchers rely on numerical values obtained from statistical procedures and their corresponding p values, whereas qualitative researchers rely on excerpts from the actual voice of participants to describe and support the identified themes.
- All research must consider essential ethical principles to ensure that participants are not harmed, either in the process of data collection or by the presentation of results.

Correspondence: Dr. Mohsen Tavakol, Medical Education Unit, University of Nottingham, Nottingham NG7 2UH, UK. Tel: +44(0)115 823 0014; E-mail: mohsen.tavakol@nottingham.ac.uk

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What is medical education research?

Research is '. . . investigation or experimentation aimed at the discovery and interpretation of facts, revision of accepted theories or laws in the light of new facts, or practical application of such new or revised theories or laws' (Merriam-Webster 2013). The ultimate goal of research is to gain new knowledge that can then be added to a body of existing knowledge in order to develop new insights and create more useful knowledge to solve a problem. Medical education research is a careful or systematic study designed to answer the fundamental questions raised by medical educators in order to make educational decisions that can be based on rigorous research-based findings rather than personal experiences.

Understanding of the knowledge construction process

Paradigms

Medical educators are always faced with questions in the real world, such as why do students struggle to learn genetics or does using a video improve learning? They use specific methods based on their own views of the world in order to find out the best answers to these questions. In the terminology of research, a paradigm is a comprehensive belief system or a worldview that provides a general perspective or framework to guide an understanding of the phenomenon under investigation. Hence, paradigms direct medical education researchers to employ the optimal methodological techniques given the nature of the phenomenon under study. According to Guba (1990), the paradigms that are adopted by educators respond to three questions: (a) What is the nature of reality (known as ontology or metaphysics)? (b) What is the nature of knowledge, its limitations and its relationship to the researcher (known as epistemology)? (c) How should the researcher go about finding out knowledge (known as methodology, by which the researcher chooses to conduct the investigation of the phenomenon)? For example, researchers may employ a cross-sectional design with one of the quantitative research traditions to answer their questions. The ontological and the epistemological questions focus on philosophical issues underlying research paradigms. In medical education research, there are a variety of research questions that may be raised by medical educators. Answering these questions requires the use of different types of research paradigms. Two main paradigms that guide disciplined inquiry in medical education, the positivist paradigm and the naturalistic paradigm, are discussed below.

The positivist paradigm

Epistemologically, over the last few centuries, the positivist paradigm was dominant to create new knowledge. It was introduced by Descartes in 1637. For Descartes, there is an objective reality that is directly observable and this can be measured using mathematical models that can predict future events. He believed that the researcher must distance him/herself from the participant to avoid any distortion of the interpretation of the findings from the study. Positivists believe that objective collection of data and its analysis must be independent of the opinions of the researcher. In Table 1, the ontological, epistemological and methodological assumptions of the positivist approach to research are summarised.

Within positivism, a hypothesis is derived from a theory and then empirically tested and replicated by a neutral researcher. Based on the result of a statistical hypothesis test, the researcher identifies the relationship between cause and effect within a value-free inquiry (Denzin & Lincoln 2011). According to positivism, there is an objective knowledge that is to be discovered and human beings cannot socially construct this knowledge. The generalisation of the study results to another situation is possible within a positivism paradigm; the nature of reality is fixed, it is single (i.e. the study results either support or reject a particular hypothesis), and it is measurable (Denzin & Lincoln 2011; Rubin & Rubin 2012). A positivist researcher will neutrally rely on statistical inferences, and if the

Table 1. Some assumptions of the positivist and constructivist approaches.

Type of assumption	Positivist approach (quantitative)	Constructivist approach (qualitative)
Epistemology (what is the relationship between the researcher and knowledge)	Knowledge is uncovered by detached scientific observations. The reality is independent of any opinions of the researcher. The researcher tries to minimise subjectivity and to maximise objectivity	Knowledge is socially constructed through interaction of the researcher with research participants. The values of both the researcher and the research participants contribute to knowledge, with there is a lack of neutrality and objectivity.
Ontology (what is the nature of reality)	The reality is singular. Reality is constructed based on cause and effect inferences.	Multiple realities exist. Each study participant has a different view on the phenomenon being studied.
Methodology (What is the research process?)	Deductive reasoning: Statistical hypothesis testing Objective and measurable Validation of theories Prediction and estimation Identifying associations between variables Generalization from samples to population Rule-bound Statistical analyses Internal and external validity Sample is large or random	Inductive reasoning: theory or hypothesis construction Subjective and non-measurable Explore participants' experiences Provide rich description of the phenomenon being investigated Generate hypothesis or theory Generalisation does not matter Context-bound Sample size is small

study results do not fit a theory/model, then the theory/model can be modified and subsequently tested using statistical procedures.

Positivism was criticised by post-positivists and in the last quarter of the twentieth century was rapidly deflated (Alvesson & Skoldberg 2009). Although proponents of the positivist approach believe that there is a fixed and objective reality that can be investigated, post-positivists argue that the absolute reality of knowledge can never be obtained, it is only estimated. Post-positivism considers that the reality is captured based on multiple methods and researchers seek to test, verify and refine theories to understand the world (Creswell 2014). Post-positivist researchers begin with a theory, then collect data in order to either support or refute the theory, and then make necessary changes and collect further data to check on whether the theory is supported or refuted (Denzin & Lincoln 2011; Creswell 2014). Thus the assumptions of post-positivist mostly support quantitative inquiry approaches rather than qualitative inquiry approaches.

The naturalistic paradigm

A different perspective to understand the world is the naturalistic view, otherwise known as constructivism, and is associated with qualitative inquiry approaches. This perspective is typically considered as an approach to qualitative inquiry (Lincoln & Guba 1985; Creswell 2014). The constructivist paradigm, a social movement opposed to positivism, began with writers such as Weber and Kant (Polit & Beck 2014). According to the constructivist epistemology, 'knowledge is the result of a dialogical process between the self-understanding person and that which is encountered, whether a text, a work of art, or the meaningful expression of another person' (Smith 1990). For constructivist researchers, individuals do not passively receive knowledge, but they actively construct knowledge through engagement with each other and the social world they are living in. Uncovering and understanding the social world of individuals thus leads to the production of meaningful knowledge. The epistemological perspective of constructivism has a focus on the 'meaning-making activity of an individual's mind' (Crotty 1998; Ritchie et al. 2013). In Table 1, the ontological, epistemological and methodological assumptions of the constructivist paradigm to research are summarised.

Ontologically, from the constructionist perspective, reality is not a single (one knowable) reality, but there are multiple realties which are constructed by those who participate in the study and this reality is negotiated with the research participants. As previously mentioned, positivist researchers believe that the individual parts of reality are not interrelated and can be separated into separate dimensions. However, naturalists believe that the reality is a whole and is not divided into its parts. For example, the parts of a 'whole cloth' (as a reality) are interrelated and inseparable. By removing part of the cloth, we actually destroy the cloth (its meaning) (Erlandson et al. 1993). From an epistemological perspective, constructivist researchers collect data subjectively to explore a single overall dimension of a phenomenon so that its true meaning is captured rather than reducing it in a number of different individual dimensions of the phenomenon. Additionally, constructivist researchers consider that inquiry and knowledge are value-laden since the researcher's beliefs highly influence the interpretation of knowledge (Tashakkori & Teddlie 1998; Griffin & Museus 2011). In contrast to positivists, which have a deductive approach to analysis (i.e. they choose a theory first and based on that theory they formulate hypotheses to test), the approach of constructivist researchers is inductive (i.e. the researcher begins with the participant's perspective and then a hypothesis or theory is created which is grounded in the real-life experiences of participants). This emergent theory illuminates the phenomenon under investigation.

Inductive and deductive approaches

Knowledge is created, based on either the inductive or deductive approach. As previously pointed out, qualitative researchers use the inductive approach to generate knowledge whereas quantitative researchers use the deductive approach to generate knowledge. The process of the inductive approach (a bottom-up method of analysis) begins with exploring the specific details of participants' experience and then gradually moves to more general principles of the phenomenon being investigated (Liehr & Smith 2002). For example, suppose a clinical educator is interested in exploring the experiences of medical students in problem-based learning (PBL). The clinical educator can use an inductive approach and by using qualitative research methods, such as interviewing students who have experienced the PBL approach, he/she can generate new understanding and theory about the PBL experience. Each student has their own specific experiences but interviewing several students will identify several common themes across the students. The process of the deductive approach, on the other hand, begins with formulating a research hypothesis about the phenomenon of interest (which is usually based on a theory). The hypothesis is then tested using statistical procedures to support or refute this hypothesis. Causal explanations, generalisation and prediction may be made based on these statistical procedures. For example, suppose the same clinical educator has formulated a hypothesis entitled 'the PBL group will score higher than the non-PBL group in the communication skills course'. The clinical educator needs to consider theories that have been previously developed by qualitative researchers to develop the assessment questions and then use quantitative research methods to collect and analyse data. Therefore, quantitative researchers test theories in order to generalise the study results to the target population. Both approaches are important for generating knowledge and the choice is based on the question being investigated.

The role of theory in research

A theory is 'a set of interrelated constructs (concepts), definitions, and propositions that present a systematic view

of phenomena by specifying relations among variables, with the purpose of explaining and predicting the phenomena' (Kerlinger 1970). Fundamentally, a theory is an idea, a guess, or a speculation, which may account for reality. Theories should guide the research process both in qualitative and quantitative research methods (Morse & Field 1995). Qualitative researchers, use the inductive approach to research and explore the observed data for 'the patterns and relationships and then develops and tests hypotheses to generate theory or uses developed theories to explain the data' (Morse & Field 1995). In this approach, research questions are created by the qualitative researcher, and then data are collected in the participant's setting. Data analysis is inductively built from specific (particulars) to general themes (generating categories and themes). The themes are finally interpreted by the researcher (Creswell 2014). However, sometimes qualitative researchers use a deductive approach in the initial stage of qualitative data analysis. They can develop a template (codebook) that uses a theoretical framework in order to organise the qualitative dataset for interpretation. However, these categories may not accurately reflect the participants' views of the phenomenon under investigation. An interesting example of a hybrid approach of inductive and deductive approach was well illustrated by Fereday & Muir-Cochrane (2006).

On the other hand, quantitative researchers formulate a research hypothesis deductively from an existing theory, and then the research hypothesis is tested by gathering data. Based on the statistical procedures used for the hypothesis testing, the existing theory is either revised or supported. For example, based on the humanistic education theory (by Carl Rogers), a researcher may hypothesise that small group teaching is more effective than large group teaching and this hypothesis can be tested using statistical procedure (Lodico et al. 2010).

Quantitative researchers who do not employ a theoretical framework for their own research study, particularly those who wish to establish cause-effect relationships, may struggle to explain why some independent variables influence the dependent variables (Kawulich 2009). In quantitative studies, theory-driven investigations are essential for the generalisation of the study results. Unfortunately, in many medical educational papers, the research question or hypothesis is not connected to a theoretical framework.

Concepts, constructs and variables

In qualitative studies, the building blocks of a theory are called concepts (Brown 2010; Polit & Beck 2014). Concepts are abstractions of particular characteristics of human behaviour, such as empathy, motivation and pain (Polit & Beck 2014). Researchers are unable to directly observe concepts in the real world but can measure them indirectly as a construct. For empathy to be measured as a construct, researchers need to identify the behavioural manifestations of empathy that can be considered as proxies of empathy, such as summarising the feelings that are expressed by participants. The terms of concept and construct are often used interchangeably in research.

A variable is a concept, and as its name suggests, is something that is likely to vary. From a quantitative point of view, a concept is observable and measurable and takes different values. For example, age, gender, teaching methods all are variables as they vary from one individual to another. Quantitative researchers are interested in investigating how or why phenomena vary, and also how the variation in a variable is explained by the variation in another variable. As an example, consider the variable of 'learning' and a research study that wishes to investigate what factors can affect student learning. Motivation as a variable may be investigated as a learning factor by the researchers. Quantitative researchers quantify student performance, for example, ranging from 0 to 100. It is noteworthy to mention that if every student obtained a mark of 60, student performance would not be a variable, it would be a constant. Qualitative researchers do not quantify a variable. For example, student performance could be reported using qualitative words, such as inferior, poor, borderline, satisfactory, good and excellent.

Dependent and independent variables

Quantitative researchers make a link between the basic building blocks of theory and the basic unit of scientific studies in order to establish the cause and effect relationships between variables. For example, does an educational intervention produce improvement in the reliability of OSCEs? In this example, researchers face a cause and effect relationship between educational intervention and the improvement of OSCEs. The presumed *cause* is the independent variable (sometimes called the exposure or predictor) whereas the presumed *effect* is the dependent variable (sometimes called the response or outcome). Quantitative researchers are interested in knowing how the independent variable causes the change in the dependent variable, especially if the independent variable predicts the dependent variable (Brown 2010). Sometimes it is very difficult to decide which of two variables in a study is the independent variable and which is the dependent variable (McBurney & White 2010). As an example, consider there is an association between drug education programmes and medication compliance. It is very difficult to conclude whether drug education programmes cause medication adherence or whether a predisposition to medication adherence causes people to adhere to a medication regimen. In medical education research, there are many confounding factors that can influence the dependent variable (outcome). Sometimes researchers are unable to manipulate independent variables in order to see its effect on the dependent variable. Examples include age, gender and year on a medical school programme. Qualitative researchers, on the other hand, are not interested in quantifying associations and relationships, or in seeking cause and effect connections. They are interested in similarities and differences in patterns of association in order to explore the underlying meanings of the phenomena under investigation.

Debate over the quality of qualitative and quantitative research

At the beginning of this Guide, we discussed philosophical perspectives of qualitative and quantitative research methods. When we are speaking of research methods, most medical educators and clinicians think of research studies that have a large sample size, and are randomly taken from the population of interest. They think how to randomly assign their study participants to groups (intervention and non-intervention group). They also think of gathering numerical data in order to use statistical procedures to produce study results. Although research studies that follow these steps in the research process can be useful, it is not enough to produce knowledge about reality, especially where situations are examined through the eyes of the participants (Cohen et al. 2008). For example, how clerkship students interact with the parents of unconscious children in hospital, 'what are the processes and strategies of clinical reasoning used by the students to produce treatment?' (Khatami et al. 2012) or 'medical students understanding of empathy' (Tavakol et al. 2012). Such social situations can be explored best by a researcher who integrates him/herself in the situation and obtains ideas, feelings, expectations, perceptions, experiences and behaviour patterns from the participants' point of view (Brown 2014). Perhaps more importantly, when researchers have little knowledge about new phenomena or new meanings of phenomena, qualitative inquiry methods are the best for gaining a deeper understanding of the phenomenon from the participant's perspective (Trice & Bloom 2014). In addition, when a theory is missing, qualitative studies can be used to generate theory (Leedy & Ormrod 2005). Quantitative researchers need to be guided by theories that are developed by the qualitative researchers. Qualitative study results can shed light on phenomena that are not accurately understood in teaching and practice. In addition, qualitative research methods are 'the most humanistic and person-centred way of discovering and uncovering thoughts an action of human beings' (Halloway & Biley 2011).

The underlying distinctions between quantitative and qualitative methods and their epistemological and ontological considerations have contributed to a better understanding of research issues. However, qualitative inquiry approaches have often been criticised by quantitative researchers (who view phenomena independent of the behaviour of the researcher), who consider quantitative research results to be more objective and value-free. In medicine, 'qualitative research continues to be devalued, and is considered to be 'subjective, biased, and opinion based' (Morse 2006, 2011). Quantitative researchers also argue that qualitative research does not have a strong design, and hence they do not recommend it for funding (Morse 2006). There are arguments against the quality of the knowledge produced by qualitative inquiry: 'quality in qualitative research is a mystery to many health services researchers' (Dingwall et al. 1998). Perhaps more importantly, the highest level of evidence has been awarded to quantitative research and the importance of qualitative research has been undermined and ranked at the lowest level of evidence (Cochrane 1972, 1989; Morse 2011). It should be noted that, however, chapter 20 of the Cochrane Intervention handbook has outlined how qualitative studies can contribute to Cochrane Intervention reviews. The handbook stated 'there are many methods of qualitative evidence synthesis that are appropriate to the aims and scope of Cochrane Intervention reviews'. For example, qualitative researchers should systematically review related individual papers in order to address 'important outcomes' and 'questions directly related to the effectiveness review'. For more details, see the handbook (Higgins & Green 2011). Although the number of papers in relation to qualitative evidence syntheses is growing (McInnes et al. 2011; Marshall et al. 2012), systematic reviews of qualitative studies are not well established in comparison with quantitative studies.

Although the issue of the nature of the knowledge produced by qualitative researchers has been raised by quantitative researchers, the discrimination against qualitative methods continues (Morse 2006), 'qualitative researchers can address the issue of quality in their research... its methods, can and do, enrich our knowledge of health and health care' (Mays & Pope 2000). Criticisms about qualitative research methods are based on a lack of understanding of what is the purpose of qualitative research studies to produce knowledge for medical educators and clinicians (Brown 2014). According to Morse 'the fact that so little is generally known about what qualitative inquiry is appalling' (Morse 2005, 2006). While qualitative inquirers gain knowledge of social reality, which is completely different from quantitative inquiries, both approaches can produce a wide range of knowledge about the phenomenon under investigation. There is a growing body of evidence that suggests the combination of qualitative and quantitative methods are important (Ashley & Boyd 2006), although 'it takes time and effort to understand both styles and see how they can be complementary' (Neuman 2003). Although quantitative and qualitative inquiry methods each have different underlying epistemological and ontological assumptions about the generation of knowledge and reality, their differences do not make one better or worse than the other. They are complementary rather than contradictory. Complex research questions require complex answers which can be achieved through the integration of qualitative and quantitative approaches. Qualitative researchers have now recognised that the perspectives of participants are not enough *per se* and multiple forms of evidence are essential. Likewise, quantitative researchers have realised that the perspectives of participants can play an essential role in quantitative results (Taylor 2013). It is perhaps for that reason that mixed methods research is grown increasingly popular among researchers. We need to think first that research is about inquiry and that distinctions between quantitative and qualitative approaches 'are arguably reified more by a need to label approaches than by true differences in in purpose' (Newman & Hitchcock 2011). Approaches should act as 'servants' rather than as 'rulers' and can be considered as different tools to be used when most appropriate to answer a research question (Silverman 2010). From a learning perspective, therefore, medical educators should learn techniques that are used in both quantitative and qualitative methods.

Steps of the research process

The quantitative research processes have a linear sequence, and consists of different steps, beginning with the identification of research questions and ending with a statement answering those questions (Nieswiadomy 1998; Polit & Beck 2014). The qualitative research process, on the other hand, tends to have a nonlinear sequence (or an iterative, repeating or recursive process). For example, qualitative researchers collect data and analyse them concurrently. They immediately begin data collection and analysis with the first interview. The next interview will be planned based on this interview. This process (i.e. data collection and analysis) continues until they sense that data saturation is achieved, that is until no new themes are identified. Unlike qualitative researchers, quantitative researchers analyse their data after all of the data are gathered. Due to the nature of qualitative studies, they may have different research process flow diagrams. Figure 1 illustrates the main steps in a quantitative research study.

Defining the problem

As seen in Figure1, researchers first need to identify the problem under investigation (Ary et al. 2006). Researchers should clearly state why they want to conduct a particular study. What is the knowledge gap in the field of study that needs to be closed? What is the importance of the problem? Researchers need to provide a rational for the study that they intend to undertake. The research problem should be logically developed into a discussion of the reasoning behind the study of interest, and end with a statement of the research question. Carefully constructed research questions will facilitate the search for a solution. It is worth mentioning that some researchers state the purpose of the study instead of the research question, with the aim of the study at the end of the introduction.

Literature review

Reviewing the related literature is an important step of the research process and the research report. Literature review informs us about the feasibility of researching the study topic before proper research begins (Hart 2005). Table 2 shows how a literature review can contribute to the study topic.

Quantitative researchers conduct a literature review to gather information on what is already known about the topic and the methods that have been used to study the topic before any data are collected. This will enable the researchers to provide the rationale for the study that they are planning. Consulting the literature can be useful for both quantitative and qualitative studies without considering the researcher's paradigm (Mertens 2010). Although some qualitative researchers acknowledge the importance of doing a review literature prior to commencing their research, some believe that qualitative researchers should not review the literature

Table 2. The contribution of the literature review to the study topic (Gillis & Jackson 2002; Hart 2005; Aveyard 2010).

- Ensures a comprehensive, relevant, clear picture of the studies available on the study topic;
- Identifies the main issues related to the study topic and hence establishes the importance of the study topic;
- Identifies areas where there are consistency or inconsistency in research results;
- Determines what is known and unknown about the study topic (the knowledge gap);
- Identifies experts in the related fields;
- Helps construct a theoretical/conceptual framework for the study topic;
- Helps the researcher to plan methods;
- Identifies how other researchers have measured and analysed their data;
- Discovers instruments or tools that can be used to measure the study variables;

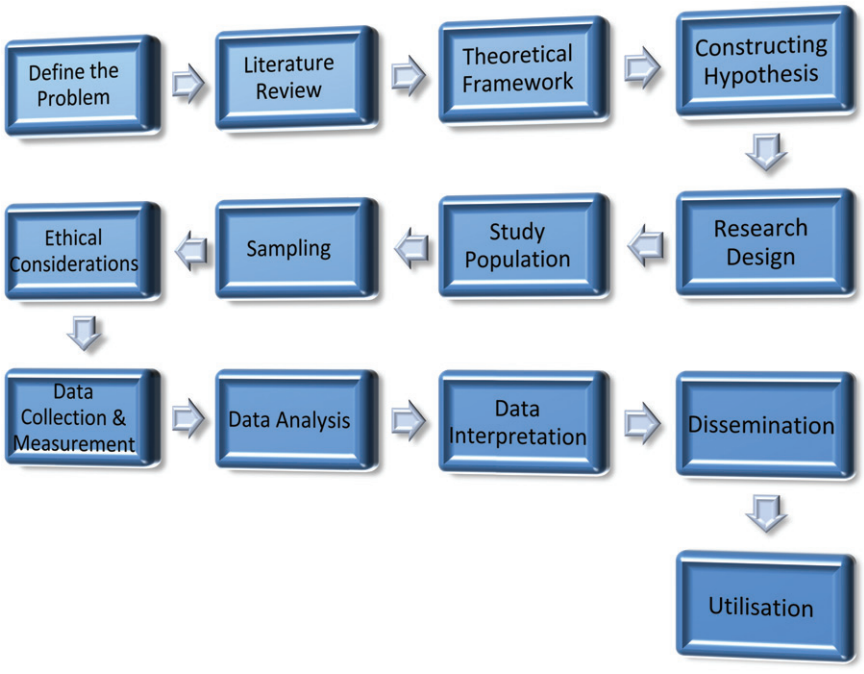

Figure 1. The main steps in a quantitative research study.

before proceeding with data collection. Opponents argue that by reviewing the literature, the conceptualisation of the phenomena under investigation might be contaminated. They believe that this should be explored based on participants' perspectives rather than prior findings (Morse & Field 1995; Polit & Beck 2014). However, others believe that qualitative researchers should be initially aware of what is already known about the phenomena under investigation, but that an additional literature review is also required during the research to make sense of the data (Marshall & Rossman 2006).

Develop a theoretical framework

Another step in the research process (Figure 1) is to develop a theoretical framework to the research study. Theories operate as a 'lens' through which to view the phenomena of interest (Sclater 2012). Theories are generated to describe, predict and understand the relation between two or more different concepts in order to construct universal laws. A theoretical framework (sometimes called a conceptual framework) is a part or a brief explanation of a theory that researchers can verify by hypothesis testing or seek answers to research questions that are driven from theory. A theoretical framework underpins the research problem under investigation, formulates the research questions or hypotheses, guides the data collection process, explains and predicts the underlying cause the phenomena under study (Reeves et al. 2008; Creswell 2014). Moan and Rise, for example, tested the use of the Theory of Planned Behaviour (Ajzen 2005) for explaining and predicting students' intentions to quit smoking and their subsequent behaviour six months later (Moan & Rise 2005).

In quantitative studies, the theoretical framework is deductively established before data are collected. Quantitative researchers report explicitly the theoretical framework of their studies in the introduction section, immediately after addressing the research questions or hypotheses. Qualitative researchers, on the other hand, generate, explain and understand a theory inductively during the research study. Theories and hypotheses are inductively generated after data analysis has begun (Morse & Field 1995). Carefully designed studies use a theoretical framework in order to guide the phenomenon to be studied. Quantitative researchers often do not explicitly discuss the theoretical framework in their reports in comparison to qualitative researchers. However, there are several educational theories that are relevant for medical education research, and these can be explored further through the work by (Kaufim 2003).

Constructing hypotheses

A hypothesis predicts the relationship between the independent variable and the dependent variable. Some quantitative studies explicitly address one or more research hypotheses but qualitative studies, on the other hand, do not have research hypotheses. This is because 'qualitative researchers want the inquiry to be guided by participants' viewpoints rather than by their own hunches' (Polit & Beck 2014). As previously stated, hypotheses are sometimes formulated from theories and often these are formulated from a large body of evidence. For example, a study hypothesised that 'women will show higher levels of empathy than will men' as this hypothesis is consistent with the previous studies (Toussaint & Webb 2005). Descriptive studies do not have a hypothesis.

A hypothesis contains the population, the independent variable, the dependent variable and a predicted relationship between them. Hypotheses are dichotomised into two groups: directional or non-directional. In a directional hypothesis, researchers can predict the direction of the association, either positively or negatively. In a non-directional hypothesis, researchers do not specify the direction of the association. Table 3 shows some examples of directional and non-direction hypotheses.

You may recall from statistics courses that there are two types of hypotheses: null hypotheses and alternative hypotheses (sometimes called research hypothesis). Researchers want to know whether or not their theories can be supported when subjected to the rigors of scientific investigations (Daniel 2005). The null hypothesis is a hypothesis of no difference (i.e. there is no difference between the independent and the dependent variables). The null hypothesis is either rejected or accepted by statistical procedures. If the null hypothesis is rejected, the alternative hypothesis is supported as the available data are incompatible with the null hypothesis (Daniel 2005). Hypotheses neither are proved nor disproved, but they are either supported (accepted) or rejected.

Study results are not always definite and researchers maybe unable to prove or disprove research hypotheses (Polit & Beck 2014). For example, consider the hypothesis that tall medical students show more empathy than shorter students. If a sample of students shows that tall medical students have higher levels of empathy than short ones, we cannot conclude that height is related to a student's empathy since in realty there is no relationship between height and empathy with patients. There are also other influences, including sources of measurement error that can influence statistical inferences, such as the accuracy of measures and factors that are not under the control of the researchers.

Table 3. Directional and non-directional hypotheses.

Type of hypothesis	Hypothesis
Directional	PBL students are better able than non-PBL students in disclosing bad news to patients with life-threatening illness
Non-directional	There is an association between PBL student and non-PBL students in disclosing bad news to patients with life-threatening illness
Directional	OSCEs better measure medical students' clinical performance than do mini-CEXs
Non-direction	There is a relationship between OSCEs and mini-CEXs with respect to measuring medical students' clinical performance.
Directional	Female medical students have more positive attitudes towards epidemiology training than male medical students.
Non-directional	Female medical students differ from male medical students with respect to epidemiology training.

Quantitative research designs

Quantitative research designs differ from qualitative research. Quantitative research designs are classified into three groups: experimental designs, quasi-experimental designs and surveys (Creswell 2013). Experimental designs explain the cause and effect relationship between the independent and dependent variables. Three important features of experimental designs (or Randomised Controlled Trials, RCTs) are: control, manipulation or intervention, and randomisation. These features help quantitative researchers to ensure that the study outcome is caused by a particular intervention rather than by other variables. Researchers control variables (major factors) which may influence the study outcome as they want to ensure that the study outcome is caused by the intervention rather than other variables (sometimes called extraneous or confounding variables). Quantitative researchers also manipulate the independent variable (cause) and then they measure its consequence on the dependent variable (effect). Another feature of experimental designs is randomisation. Researchers randomly assign study participants into experimental or control groups. The experimental group is exposed to a treatment, but the control group does not receive any treatment. Randomisation means that each participant has an equal chance of being selected to either group. By taking these features into account, researchers are able to generalise the study outcome to the population of interest. To illustrate, consider a medical educator investigating the effect of high-fidelity simulation (independent variable) on medical students' knowledge and clinical performance (dependent variable). In this example, simulation may influence knowledge and clinical performance. The medical educator can assign students to two groups randomly (i.e. each student has an equal chance of getting the experiment or control condition). Before the intervention was experienced, the educator can assess (pre-test) the knowledge and clinical performance of students in each group. Subsequently, students in the experimental group can be exposed to the simulators whereas students in the control group are exposed to a traditional intervention which was similar to the information covered in the simulator. The educator then can reassess the knowledge acquisition and clinical performance in both groups (post-test). Finally, the educator can compare the differences between the post-test scores of the two groups in order to identify the effect of the simulator on the knowledge acquisition and clinical performance, while the educator considers other variables (Figure 2). This experimental design is called a randomised control-group pre-test-post-test design (sometimes called an RCT design).

Sometimes in medical education, educators are unable to assign participants randomly to experimental and control groups, but they want to assess a particular intervention. If this is the case, educators need to follow a quasi-experimental design. Sometimes this design is called trials without randomisation. There are different types of quasi-experimental designs (Shadish et al. 2002; Harris et al. 2006) but two important designs will be discussed here: the non-equivalent control group pre-test-post-test design and one group pre-test-post-test design.

The non-equivalent control group pre-test-post-test design (sometimes called a comparison study) compares two or more groups of participants before and after a particular intervention without assigning participants to the experimental and control groups. This design is the same as the pre-test-post-test experimental design (see above), except participants are not grouped (the experimental and control groups) randomly (Polit & Beck 2014). As an educational researcher, you can compare students at medical school A as the experimental group with students at medical school B as the control group. The experimental group attend clinical simulation (intervention) activities whereas the control group attend the normal clinical programme for three weeks. Before the intervention is implemented, the clinical performance of students in two medical schools is assessed as a baseline. Data on clinical performance in both medical schools after 3 weeks – when the intervention is made – are collected to see the effect of the simulation on clinical performance.

The second quasi-experimental design is the one group pre-test-post-test design. Here, as in the previous example, the educator assesses the knowledge and clinical performance of all students before simulation training. This time, however, all students are exposed to simulation training. The difference between the pre-post test scores may be an indication of the change in the use of simulators.

As groups (the experimental and control/comparison groups) are not randomly allocated, it is impossible to say the groups are equivalent at the beginning of the study. Hence, the study findings of quasi-experimental designs are less decisive in comparison with experimental design. In the other words, if the clinical performance of students in groups is not equivalent, the effects of the intervention will not be clear.

Sometimes researchers are not able to randomise participants into groups or they cannot manipulate the independent

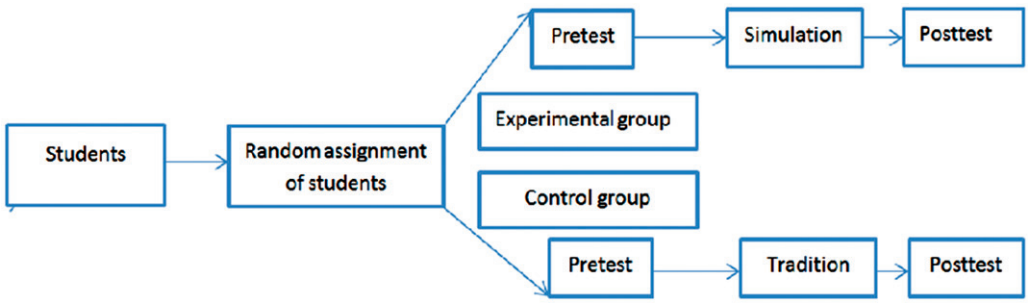

Figure 2. Randomised control-group pre-test–post-test design.

variable in order to observe its effect on the dependent variable. This could be due to ethical considerations or to factors out of the control of the researcher. For example, consider gender as an independent variable; if researchers want to compare female and male students about a particular phenomenon, they cannot manipulate gender and they cannot randomly assign students to be either female or male. When the researcher has no control on the independent variable, the study is non-experimental (sometimes called an observation design). This design is widely used in medical education research. There are different non-experimental designs, but three study designs which are commonly used in medical education research will be discussed: correlational studies, cross-sectional studies and longitudinal studies.

Sometimes when researchers wish to establish a relationship between the variables in their study, but they cannot design an experimental or quasi-experimental study, they plan for correlational studies. In correlational studies, researchers make a claim about the relationship between variables in theories or models. For example, what is the relationship between student ability and their score on the UK Clinical Aptitude Test (UKCAT)? By calculating the correlation between students marks and UKCAT scores, researchers can address the association between student ability and UKCAT.

In cross-sectional studies, researchers collect data at one point in time or over a short period (Kevin 2006). In this design, independent and dependent variables are identified in a given population and then the associations between them are determined. For example, medical educators may be interested to determine the association between medical student year and empathy. If the researchers have knowledge of the medical student year and the empathy scores of students, they will be able to identify the relationship using statistical procedures. In epidemiological studies, retrospective studies or prevalence studies are usually cross-sectional. Data on the independent and dependent (outcome) variables are collected simultaneously (Polit & Beck 2014).

Sometimes study participants are followed over time and data are collected at multiple follow-up times. This is called a longitudinal study. In other words, the same participants are measured 'at each point of the time scale'. Such studies are always concerned with individual change (Goldstein 1968). As an example, a longitudinal study 'was designed to examine changes in medical students' empathy during medical school and to determine when the most significant changes occurs' (Hojat et al. 2009). In epidemiological studies, prospective studies or incidence studies are usually longitudinal. Cohort studies are longitudinal studies which involve a large sample size. The interested reader is referred to the book 'A study guide to epidemiology and biostatistics' for a discussion of the epidemiological studies (Hebel & McCarter 2012).

Conclusions

This part of the Guide has explained how quantitative and qualitative methods can be used in medical education research to produce new knowledge. From a learning perspective, therefore, medical educators should learn techniques that are used in both quantitative and qualitative methods. Although the philosophical assumptions of quantitative research differ from qualitative research, they certainly do not contradict each other, but they are complementary. From a quantitative perspective, a concept is observable and measurable, and is analysed using statistical procedures. From a qualitative point of view, the phenomenon of interest does not quantify, but the qualitative researcher provides a rich description of the phenomenon to be studied. In quantitative studies, the research process is linear and deductive, whereas in qualitative studies the research process is recursive and inductive. In this part, we have also explained some essential steps in the research process and quantitative methods.

Notes on Contributors

MOHSEN TAVAKOL, PhD, MClinEd, is a Lecturer in Psychometrics. His main interests are in medical education assessment, psychometric analysis (Classical Test Theory, Generalisability theory, Item Response Theory Models), robust statistical methods, multivariate statistics, quantitative and qualitative research methods and communication skills.

JOHN SANDARS, MD, MSc, FRCGP, FAcadMEd, MRCP, Cert Ed., is an Associate Professor at the Leeds Institute of Medical Education, University of Leeds, UK. His main interest is in developing teaching and learning by a scholarship approach, in which real life problems are investigated by both quantitative and qualitative research.

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