

The Role of Qualitative Research in Science Education

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In the paper the qualitative research in which the researcher has been directly involved, and has himself been examining the research phenomenon in the studied environment, is presented. The aim of this qualitative study is to gather data in the form of rich content-based descriptions of people, events, and situations by using different, especially non-structural, techniques to discover the stakeholders' views and similar, to orally analyze the gathered data, and finally to interpret the findings in the form of a concept or contextually dependent grounded theory. The main purpose of the paper is to identify research approaches used by authors who have published in respected international science education journals in the last three years. It can be concluded from the results that authors have been using qualitative and mixed research approaches in more than half of the published papers in the last three years in order to address the research questions in their studies.

Keywords: Qualitative research, Science education, Document analysis, Journal analysis.

INTRODUCTION

Authors who publish papers in respected science education research journals always try to make some efforts to bridge the gap between science education research results and conclusions and their applications in the educational process at all levels of education. This paper presents some methodological aspects that are important for the field of science education research. The selection of the appropriate methodological approach is always an important step in the science education planning process. The science education researcher should, before choosing the method, precisely address or identify the research problem. According to the identified research problem the researcher should ask research questions about it.

The research questions asked should be researchable, take into account the subjects who are participating in the study, ought to address the research problem, and measure the variables that you wish to measure, and

should also give some clear answers or - in other words - should have a clear »take home« message (Bunce, 2008).

Research problems and research questions provide an important guideline for the researcher in selecting the appropriate research methodology or methods designs: quantitative, qualitative and mixed methods designs.

For the purposes of this paper only the qualitative approach to science education research will be described in more detail, and the methodology approaches used by the authors who publish in respected science education journals will be analysed. At the end, some insight for future science education research will be placed into the perspective of where science education research is heading.

CHARACTERISTICS OF QUALITATIVE RESEARCH

Qualitative research, regarding its ontological, epistemological and methodological aspect, is not a consistent phenomenon; namely, it combines different kinds of research, e.g. a case study, life history, action research and the like. Bogdan and Biklen (2003) use the term »qualitative research« as the superordinate concept, joining different research approaches with certain common characteristics as well. With the expression

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State of the literature

- There are not many papers about methodological approaches in science education research published in respected journals.
- Some aspects of qualitative paradigm of pedagogical research seem to be an important approach recently, but there have not been done a systematic analysis of the methods used in the published papers.
- Three research questions were addressed in this paper, were about methodological approaches that prevail in papers published in the last three years in the field of science education research, about data gathering methods in the qualitative and mixed research papers and was a triangulation of methods used in there papers?

Contribution of this paper to the literature

- The largest part of the analyzed papers was about science in general, rather than biology, chemistry or physics.
- The qualitative research approach was used most frequently, following by quantitative and mixed approach. The authors most frequently use interviews for gathering data following by observations and document analysis. The authors used triangulation of qualitative data gathering methods in only 39.2% of the published qualitative or mixed research papers.
- It can be concluded from the analysis of the papers published in three respected science education journals that, similarly as in the field of general sociological and pedagogical research, the qualitative research approach for gathering data prevails.

»qualitative research«, the research is denoted as consisting of the basic empirical material, collected in the research process, which is verbally described or narrated. Furthermore, the collected material is worked on and analyzed in words without numerical operations (Mesec, 1998). In other authors, (e.g. Denzin & Lincoln, 2000; Creswell 1998) similar definitions of qualitative research are found. According to Creswell, qualitative research is the research process designed according to a clear methodological tradition of research, whereby researchers build up a complex, holistic framework by analyzing narratives and observations, conducting the research work in the habitat (Creswell, 1998). Fraenkel and Wallen (2006) draw attention to the fact that qualitative researchers mainly focus on the examination of characteristic traits or properties of a certain activity, group, situation, or materials, respectively, but they are not much interested in the frequency of appearance of

this activity, group, situation, or material. »Qualitative« research is an exploratory approach emphasizing words rather than quantification in gathering and analyzing the data. It is a matter of the inductive, constructivist and interpretative exploratory approach with the following main stresses: to view the world with the eyes of the examinees, to describe and take into account the context, to emphasize the process and not only the final results, to be flexible and develop the concepts and theories as outcomes of the research process (Bryman, 2004).

To summarize, for qualitative research it is characteristic that data are gathered more in a verbal and visual than in a numeric form. When analyzing the gathered data, statistical procedures are also not used, but instead predominantly qualitative analysis, the essence of which is searching for codes in the analyzed materials (Bryman, 2004). The main part of the qualitative analysis of the material is formed by the coding process, i.e. interpreting the analyzed text and attributing the meaning (of key words, notions, codes) to its individual parts (Charmaz, 2006; Bryman, 2004; Flick, 1998), respectively. Qualitative analysis of the material starts with defining the coding units, followed by the appropriate phenomena records according to our judgment and analyzing the characteristics of these phenomena, and ends with the development of the grounded theory (Glaser & Strauss, 1967). The grounded theory is read out as a narrative about the phenomenon which was the subject of the study. It is characteristic for the theory to be constructed from the collected data and to develop in the course of the entire research process. The grounded theory is contextually bound, i.e. it is not a general theory (the findings cannot be generalized without additional definitions), but a theory of narrower scope, valid only in certain environments and in certain conditions.

Qualitative empirical research is oriented towards examining individual cases (idiographic approach). The study is mostly conducted as a study of one case only or a smaller number of cases, therefore the techniques of data collection are adjusted to a small scale analysis, enabling the researcher to get to know the social environment. In data collection one is not limited to one source or one technique only. Apart from the data acquired by interviews and observation, usually also different documentary sources are used, such as personal documents (a birth certificate, an employment record, a passport, letters, photos etc), different records produced in the process of data collecting, transcriptions of tape recordings, video shots, etc. Only the triangulation – the pluralism of data collection techniques and their mutual combination - can provide for linking the findings of individual phenomena or aspects into a meaningful integrity. According to the conventionally accepted definition, triangulation is the

use of multiple methods in the study of the same object (Denzin, 1978; Richardson, 2003; Bryman, 2004). Triangulation was first used as a technique for checking the validity of the research findings (Flick 1998; Tashakkori & Teddlie, 1998; Neuman, 2003; Bogdan & Biklen, 2003; Richardson, 2003; Bryman, 2004; Stake, 2005), based on the belief that we could reject or acknowledge the research hypotheses only if we had come to the same conclusions by means of different methods. Nevertheless, later, the importance of triangulation, as well as its employment, increased significantly. Denzin (1978) extended the notion of triangulation, saying that triangulation of methods is only one form of triangulation. In his opinion there are also data sources triangulation, the investigator triangulation and the theory triangulation (about this, see also: Flick, 1998; Tashakkori & Teddlie, 1998; Neuman, 2003; Janesick, 1998). Janesick (1998) added the fifth triangulation form, namely the scientific discipline triangulation. The comprehension that triangulation is not merely a technique for validating the scientific findings, but that it also provides for a more thorough understanding of each researched phenomenon, was increasingly extended. Triangulation is not a tool or a strategy of validation, but an alternative to validation. The combination of multiple methodological practices, empirical materials, perspectives, and observers in a single study is best understood as a strategy that adds rigor, breadth, complexity, richness, and depth to any inquiry (Flick, 1998; Denzin & Lincoln, 2005). Triangulation is a strategy enabling researchers to understand the observational object significantly better and in a more comprehensive manner. Multiple triangulation, assuming the combination of multiple triangulation forms, i.e. the triangulation of investigators, theories, data sources, methods and/or disciplines, provides for the exhaustive data interpretation.

Qualitative research is carried out in line with the principles of the interpretative paradigm, i.e. the focus is on examining the subjective experiences of an individual and on recognizing the importance which the individual attaches to specific events, whereby not even the subjective views of the researcher of the studied situation are neglected. The aim is to achieve integrated and detailed cognition of phenomena, preferably in natural and concrete circumstances, for the researcher is interested in the context of the pursued activities. As part of the environment, not only is the researcher able to understand what the person is conveying in the form of a rational message and standardized speech, but also the indirect implications of this speech with a specific syntax, contextual lapses, hidden meanings and speech breaks are perceived. Wishes, expectations, interests, needs and personal opinions of the people included into the research should help the researchers to better

comprehend the examined phenomena. In this context, the researcher should be aware of the fact that with their participation - and with the researched situation itself - they are influencing the events they are observing, and the discursive reality, as their research object.

Purpose and research questions

The analysis of the research papers published in three major science education research journals is presented in this paper. It was hypothesised that the qualitative research paradigm was used in the papers published in the last three years as often as was a quantitative or mixed one. The research questions addressed in this paper were: (1) which research approaches prevail in papers published in the last three years in the field of science education research?, (2) which data gathering methods were used by the researchers in the qualitative and mixed research papers?, and (3) how often was a triangulation of methods used in the qualitative and mixed researches?

METHOD

Sample

This section of the paper presents results of the analysis of methodology used in the research papers published in three major science education research journals; International Journal of Science Education (IJSE), Journal of Research in Science Teaching (JRST) and Science Education (SE). These three journals are also included in the Social Science Citation Index and they had impact factors as released by the Institute for Scientific Information, Thomson Reuters (USA), Journal Citation Reports for the year 2007 as follows: JRST 1.148, SE 0.936 and IJSE 0.541. Special issues of the journals and books reviews were excluded from the analysis.

Research design, data collection and analysis

The research was a non-experimental, cross-sectional and descriptive study (Bryman, 2004). In the first step of analysis, the full text papers' methodology was read by two authors of this paper. Two authors, trained to analyze the text and code the data by using the designed coding sheet, independently coded the selected data. The analysis and coding process were performed in several steps. According to the first step of analysis, the categories of research approaches used by the authors in selected published papers were identified. Both authors gave consent about the derived codes, and a coding sheet was developed. The data obtained by the document analysis were entered into the excel file and additionally coded and added into the coding sheet. The

Table 1. Number of published pages in the selected journals.

Journal	2006	2007	2008*	Sum by Journal
JRST	1109	1478	970	3557
SE	1143	1030	1126	3299
IJSE	1904	1929	1835	5668
Sum by year	4156	4437	3931	12524

* - not all issues have been published yet in the current publication year

derived codes were divided into categories according to the qualitative research approaches (e.g. interview, observation, document analysis). If the coding scheme was modified when new codes emerged from the data as the data analysis proceeded, consent about the new code was given by both authors. The agreement on the methodology approaches identified in the published papers in the selected respected journals was calculated at 96 %. The codes derived from the coding sheet were counted, and frequencies and percentages were used to present the results.

RESULTS

Altogether 12,524 pages of research reports were published in three years in the selected journals. More than 4100 pages of research material were published each year, and more than 3200 pages in JRST and SE, and even more than 5600 pages in IJSE (Table 1).

JRST published 146 papers, SE 127 and IJSE 188 papers in the last three years. According to these data,

IJSE published 42 papers more than JRSE and 61 research reports more than SE.

Analysis of the scientific fields to which papers were dedicated in JRST shows that in the JRST there were altogether 64.8% of papers dedicated to science in general, 10.3% specifically to biology, 12.4% to chemistry, 10.3% to physics and 2.8% to other fields (biochemistry, geography or other fields).

Analysis shows that 73.2% of all papers in SE covered general science education problems. 11.8% of papers were dedicated to biology, 7.9% to chemistry, 6.3% to physics and 0.8% to other fields.

Results show that 105 (55.9%) of all papers published in IJSE discussed general problems in science education, while 35 papers (18.6%) researched biology education, 24 chemistry and 23 papers physics, that is 12.8% and 12.2% respectively of all papers published in this journal in the last three years.

Figure 1 shows the percentages of scientific fields in all three analyzed journals according to publication years.

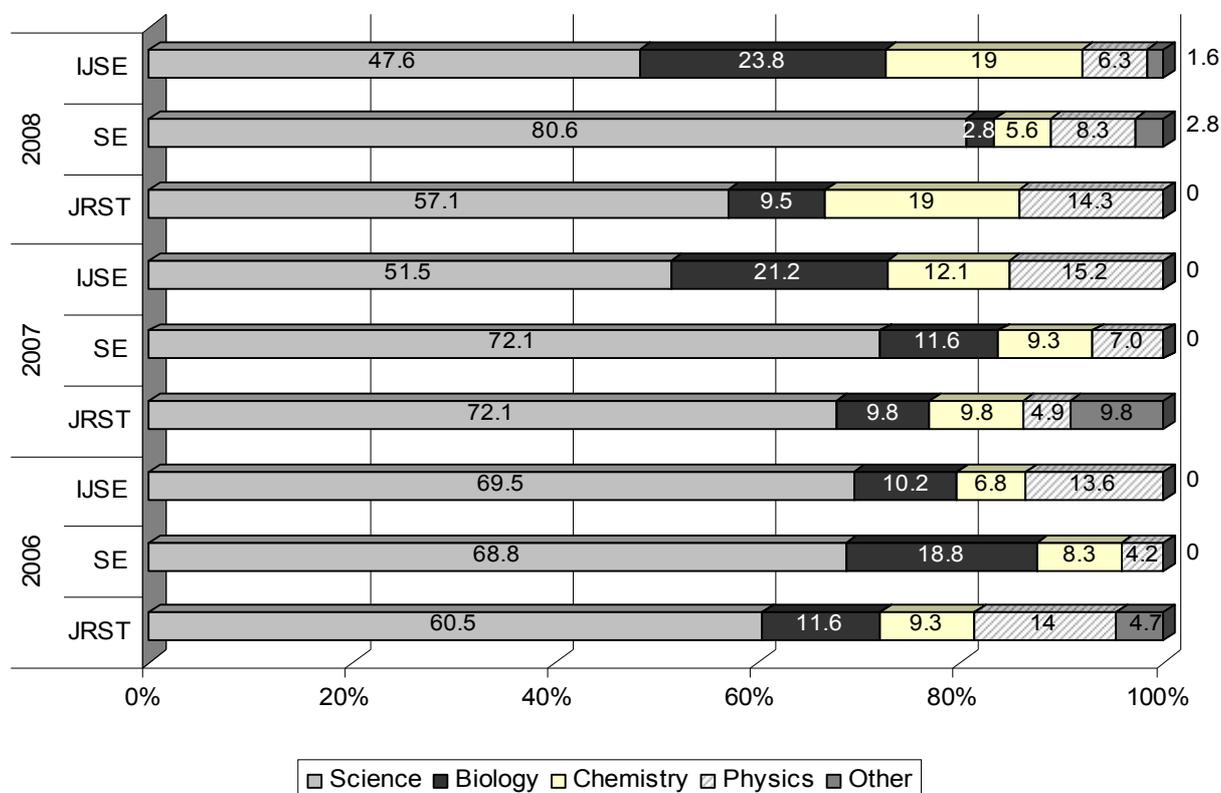


Figure 1. Scientific fields discussed in papers published in analyzed journals each year.

From the analysis of the methodology used in the papers published in JRST from 2006 to 2008 it can be concluded that authors from 65 papers (44.83%) used the qualitative research approach. Authors of 36 papers (24.83%) used mixed methods design, and 43 papers (29.66%) used quantitative methods to answer the research questions. Only two papers (1.38%) were theoretical in nature.

From analysis of the methodological approaches used in papers published in SE, it can be seen that more papers (68 or 53.54%) used qualitative research to answer the research questions than in JRST. According to these data it can be expected that mixed or quantitative research approaches were used in fewer papers than in JRSE. The data show that 20.47% of papers used mixed methodology, and only 13.39% of papers published in SE used some form of quantitative research approach. It can be also concluded from the results that 16 papers published in SE (12.6%) were theoretical or review papers.

Data analysis shows that a greater number of quantitative methodology research papers were published in all three years in IJSE than in SE. A similar

number of papers with specific methodological approaches were published in JRST: 75 papers (39.89%) discussed research quantitative in nature and 62 papers (32.98%) presented qualitative research in IJSE. Authors that published papers in IJSE used mixed methodology on average in fewer studies (37 papers or 19.68%) than authors that published in SE or JRSE. There were also 14 (7.45%) theoretical or review papers published in the last three years in IJSE.

It can be summarized from Table 2 that JRST published a similar number of papers using different research methodologies in the last year. Qualitative research approaches predominate over quantitative and mixed methods in publication year 2006, but there were similar percentages of papers published using qualitative and quantitative research methods in year 2007. The results also show that mixed research approaches represent the lowest percentages of methods used by authors of all papers published in JRST.

It can be concluded from Table 2 that SE published a similar percentage of papers which used qualitative or mixed methodology in years 2006 and 2007 as did JRSE. There were about 21% fewer papers with quantitative

Table 2. Results of the analysis; type of research methodology used in selected journals.

Journal	Research methodology	Publication year						Sum f
		2006		2007		2008		
		f	f%	f	f%	f	f%	
JRST	Quantitative	6	13.95	23	37.70	14	33.33	43
	Qualitative	24	55.81	26	42.62	15	35.71	65
	Mixed	12	27.91	12	19.67	12	28.57	36
	Theoretical or review	1	2.33	0	0	1	2.38	2
SE	Quantitative	7	14.58	7	16.28	3	8.33	17
	Qualitative	25	52.08	20	46.51	23	63.89	68
	Mixed	9	18.75	8	18.60	9	25.00	26
	Theoretical or review	7	14.58	8	18.60	1	2.78	16
IJSE	Quantitative	22	37.29	20	30.30	20	31.75	62
	Qualitative	21	35.59	26	39.39	28	44.44	75
	Mixed	8	13.56	17	25.76	12	19.05	37
	Theoretical or review	8	13.56	3	4.55	3	4.76	14

Table 3. Results of the analysis; type of data collection in qualitative and mixed research methodology approach in selected journals.

Journal	Data gathering methods	Publication year						Sum f
		2006		2007		2008		
		f	f%	f	f%	f	f%	
JRST	Interview	26	72.2	25	51.0	19	70.4	70
	Observation	18	50.0	22	44.9	13	48.2	53
	Document analysis	8	22.2	15	30.6	8	29.6	31
SE	Interview	23	67.7	16	57.1	23	71.9	71
	Observation	18	52.9	20	71.4	19	59.4	57
	Document analysis	13	38.2	7	25.0	14	43.8	34
IJSE	Interview	24	82.8	29	67.4	20	50.0	73
	Observation	11	37.9	14	32.6	20	50.0	45
	Document analysis	8	27.6	14	32.6	15	37.5	37

research approaches published in SE than in JRSE, but there were over 18% more theoretical papers in SE than in JRST in 2007. The most obvious difference between the JRST and SE is in the number of theoretical or review papers published in each journal in years 2006 and 2007. The SE published more theoretical papers than did JRST. But comparing the type of methodology used in papers published in the last year in SE and JRST, it can be seen that SE published 28.18% more papers using qualitative research than JRST. The percentage of papers using mixed methodology or theoretical papers is similar in both journals, so it can be concluded that SE published 25% fewer papers with quantitative methods than JRST.

Further analysis of the methods for gathering data in papers published in JRST revealed that the authors of qualitative researches most frequently used interviews: 70 papers or 69.31%. The next type of data - gathering methods are observations that were used by authors in 53 (52.48%) published papers. The last method of qualitative approach, document analysis, was used in 31 (30.69%) papers. Authors used different ways of recording the data, the most frequently used being video and audio recordings and fieldnotes.

Similar results were obtained by analyzing the qualitative data - gathering approaches that were used in papers published in SE: 62 (65.96%) of papers revealed that the authors gather data using interviews, 57 (60.64%) observations and 34 (36.17%) document analysis. It can be also summarized that authors used video or audio recordings of classroom situations, or some other students' or teachers' activities, in 18.9% of all papers published in SE in the last three years.

More than 65% (73 papers) of all qualitative methodology papers published in IJSE used interviews for gathering data. Fewer papers (45 papers or 40.18%) published in IJSE than in JRSE and SE used observations, and about the same percentage of published papers (37 or 33.04%) used document analysis.

More detailed results of different qualitative methods used by the authors regarding the publication year of the analyzed journals are presented in Table 3.

The analysis of the number of different qualitative approaches used in the papers by the researcher revealed that, in the papers published in the JRST, 63 papers (63.38%) used only one qualitative research approach to gather the data. Two different qualitative methods to gather data were used by the researchers in 23 (22.77%) of the papers, and in only 15 (14.85%) did the authors use all three methods (interview, observation and document analysis) to gather data in their research. It can be concluded that only 38 qualitative research papers published in JRST were reports of research that used triangulation of different qualitative methods in the data collection process.

On the other hand, in 49 (52.13%) published papers in SE only one method of qualitative research was used; 30 (31.91%) of papers present two qualitative methods and only 15 (15.96%) of papers used all three methods of qualitative research to answer the research questions. The results show that there are a few more papers published in SE that use more than one method for collecting qualitative data than in JRSE.

Again, similar results are to be found by analyzing the qualitative papers published in IJSE to those in JRSE regarding the triangulation of qualitative methods for collecting data: 74 papers or 66.07% used only one method, 31 papers (27.68%) two and only 6 papers (5.36%) used all three methods for collecting qualitative data.

Comparing the results of analysis of all three journals, it can be concluded that authors publishing in IJSE rarely use the triangulation of interview, observations and document analysis in one study.

CONCLUSION

Two paradigms of scientific research were developed in the past. Regarding their attributes, they are called quantitative and qualitative. In the presented paper, the expression »paradigm« is used in the sense of Kuhn's contemporary definition of scientific paradigm. According to Kuhn, paradigms are »the series of reciprocally connected assumptions about social phenomena, providing the philosophical and notional frame for studying them« (Kuhn 1974, p. 39). Therefore, the paradigm is the sum of values, convictions, assumptions telling us which values, beliefs, convictions, assumptions, laws etc., regarding research in the scientific discipline, are shared by the adherents of a certain scientific paradigm. In accordance to them, they form their tradition of scientific research.

The main aim of quantitative research is to obtain reliable, exact, precise, measurable, objective and valid results. The use of the standardized research instruments, distinction between the research subject and the research object, use of statistical methods, forming hypotheses and their reliable verification are some of the major methodological principles of the empirical-analytical methodology.

In qualitative research, the collected data are more in a verbal and pictorial form than in a numerical one. There is also a tendency to incorporate an integral and in-depth comprehension of phenomena in as natural a setting as possible, as well as in the context of concrete circumstances (Mesec, 1998). The crucial instrument of the empirical research is the researcher, since he/she is directly included into the environment, which helps him/her to observe the object of the research.

From the analysis of the papers published in selected journals, it can be concluded that altogether 12,524

pages of research reports were published in three years. Journal of Research in Science Teaching published 146 papers, Science Education 127 and International Journal of Science Education 188 papers.

It can be also summarized that the largest part of the papers were dedicated to science in general, rather than to biology, chemistry, and physics. Pedagogical research into other fields of science (e.g. biochemistry, geography) was published only in a few papers.

In answering the first research question, concerning which research approaches prevail in papers published in the last three years in the field of science education research, it can be concluded that the qualitative research approach was used most frequently by the authors. In all three analysed journals, qualitative research was used in 45.1% papers, quantitative research was used in 26.5% papers, mixed approach (combination of qualitative and quantitative research) was used in 21.5% papers, and 6.9% of papers were theoretical.

From the analysis of the methods for gathering data in papers published in a selected journal - in response to the second research question - it can be concluded that authors most frequently use interviews (in about 45.7% papers). The other two methods of qualitative data gathering - observations (32.9%) and document analysis (21.7%) - were used in fewer papers.

The third research question concerns the quantity of a triangulation used in the qualitative and mixed researches. It can be summarised that authors used triangulation of qualitative data gathering methods in only 40 (39.2%) of the published qualitative or mixed research papers, and 62 (60.8%) of the papers used only one method to gather qualitative data. Two qualitative methods were used by authors of 28 papers, and only 12 authors triangulated all three qualitative methods to answer in depth to their research questions.

It can be concluded from the analysis of the papers published in three respected science education journals that in science education, research similarly as in the field of general sociological and pedagogical research, the qualitative research approach prevails.

A major strength of the qualitative approach is the depth in which explorations are conducted and descriptions are written, usually resulting in sufficient details for the reader to grasp the idiosyncracies of the situation. The ultimate aim of qualitative research is to offer a perspective of a situation and to provide well-written research reports that reflect the researcher's ability to illustrate or describe the corresponding phenomenon. It can be expected that the majority of the research is going to be based upon the qualitative research paradigm in the future, because of the advantages that the qualitative approach introduce into science education research. The disadvantages of the qualitative research approach (e.g. inability to generalize

the research findings from the sample to the population, pure objectivity etc.) could be diminished by using the combination of qualitative and quantitative research approaches in so called mixed researches.

In conclusion it can be recommended that the researcher, when selecting the research approach (e.g. qualitative, quantitative or mixed), should always set out from the concrete research problem and research questions or hypothesis. On the basis of the research problem, the researcher should decide which research approach is going to lead him/her easily, swiftly and most efficiently to the most reliable findings that adequately answer the research questions.

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