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International Trends in Biology Education Research from 1997 to 2014: A Content Analysis of Papers in Selected Journals

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This paper provides a descriptive content analysis of biology education research papers published in eight major academic journals indexed in Social Science Citation Index [SSCI] of Thomson Reuters® from 1997 to 2014. Total of 1376 biology education research [BER] papers were examined. The findings indicated that most of the papers were published in the JBE and IJSE, and frequently studied topics were environment and ecology, genetics and biotechnology, and animal form and function. The findings were also indicated that learning, teaching and attitudes was in the forefront as the frequently investigated subject matters, undergraduate and secondary school students were mostly preferred as sample group and sample size mostly varies between 31-100 and 101-300. In addition, it was found out that interactive qualitative research designs were mostly preferred. Besides, that single data collection tool was generally used and this data collection tool included questionnaires, interviews and documents. Finally, frequency/percentage tables, central tendency measures, statistical analysis such as t-test and ANOVA/ANCOVA and content analysis were commonly used as data analysis.

Keywords: *biology education, research paper, content analysis, document, research trends.*

INTRODUCTION

In the late 1800s and early 1900s, concerns about the quality of learning and teaching science at the postsecondary level began to emerge, marking the first steps toward discipline-based education research (DBER) (Rudolph, 1990). Over time, however, biology faculty members have begun to study increasingly sophisticated questions about teaching and learning in the discipline. These scholars, often called biology education researchers, are part of a growing field of inquiry called DBER (Singer, Nielsen, & Schweingruber, 2013).

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DBER have emerged as a field of inquiry from programs of research that have developed somewhat independently in various disciplines in the sciences and engineering (Singer et al., 2013). However, although concerns about the quality of biology education research [BER] have emerged more lately than the other fields of DBER such as physics, chemistry and engineering, BER can make an important contribution to development of biology education.

State of the literature

- Discipline-based education research [DBER], which combines knowledge of teaching and learning with deep knowledge of discipline-specific science content, plays an important role in forming of the education and teacher training.
- Biology education research [BER] is one of the DBER sub-disciplines and it can provide an important contribution to the quality of biology education.
- In recent years although the number of BER papers are increasing there are few studies reviewing the BER literature. This indicates a need for an additional step to do a extensive analysis of BER.

Contribution of this paper to the literature

- This study indicates more in detail evolution of BER and trends identified in previous studies and scrutinizes the BER papers in terms of different variables such as content and the methodological point of views.
- This paper analyzes the BER papers in terms of all biology topics in DBER, while previously studies were generally emphasized on science education trends with an interdisciplinary approach.
- This study provides a descriptive content analysis to cover recent trends through analyzing the papers published between 1997 and 2014.

The emergence and development of biology education research in DBER

Discipline-based education research (DBER) is grounded in the science and engineering disciplines and it also investigates learning and teaching in a discipline using a range of methods with deep grounding in the discipline's priorities, worldview, knowledge, and practices. DBER is also playing a critical role in faculty members' efforts for improving instruction (Singer, Nielsen, & Schweingruber, 2012).

DBER is conducted both at the disciplinary level and post-secondary level by scholarly researchers who are trained in both discipline and educational research methods and who have the intention of publishing findings that are generalizable to other learning settings within the discipline (Action Research, SoTL, DBER, nd). DBER scholars have also examined learning and teaching in the K-12 context, particularly at the high school level. Thus, the research has the practical goal of improving science and engineering education for all students. Achieving these goals requires that DBER studies be grounded in expert knowledge of the discipline and the challenges for learning, teaching, and professional thinking within that discipline (Singer et al., 2012).

As indicated above, major emphasis of DBER is the development of a scholarship of teaching and learning. A quarter century ago Boyer (1990) emphasized the need for classroom research and that scholarly teaching should receive equal emphasis with disciplinary research (Offerdahl et al., 2011). At about the same time, some practitioners used assessment results to measure and enhance the effectiveness of their teaching (sometimes called action research), and this tradition came to be known as the scholarship of teaching and learning [SoTL] (Hestenes, Wells & Swackhamer, 1992; Offerdahl, 2011). Kreber and Cranton (2000) defined three perspectives for SoTL. The first perspective on the scholarship of teaching is parallel to the traditional conceptualization of scholarship. In the second perspective, scholarship of teaching is equated with excellence in teaching. And, in the third perspective, scholars of teaching take a scholarly approach to teaching by applying educational theory and research to their practice.

The relation of SoTL to DBER has been the subject of considerable debate (Boshier, 2009). SoTL emphasizes developing reflective practice and using classroom-based evidence. Some faculty engages in SoTL to inform their own work in the classroom, and some have gone on to become deeply engaged in more general education research. Thus, the boundaries between SoTL and DBER are blurred and some researchers belong to both the SoTL and DBER communities (Singer et al., 2012). In a general framework, DBER sub-disciplines exist in chemistry, biology, engineering, and mathematics (Offerdahl et al., 2011). Undergraduate biology education research (BER) is probably the most recent DBER field to have emerged (Dirks, 2011).

Biology is organized into a large number of subfields with many professional societies. In contrast, the BER community is emerging in a more centralized way. In 2010, the BER community established the Society for the Advancement of Biology Education Research [SABER] with the explicit goal of advancing the field of undergraduate BER. The formation of SABER, which cuts across the biological subfields, should attenuate this disparity with its singular focus on education research (Singer et al., 2012).

It is important to understand the developmental path of biology education researches (BER). Because, for researchers, information about the current status and trends of research in their fields is helpful for their career and academic publications (Lee, Wu, & Tsai, 2009). Similarly, being aware of publications in important academic journals for novice researchers helps them to understand the field of science education more broadly. Therefore, a systematic analysis of publications in academic journals may assist researchers to explore the current status and future trends of researches (Tsai & Wen, 2005). In this way, it will be possible to guide many scientists who make studies and researches on this issue (Cohen, Manion & Morrison, 2007).

There are few studies reviewing the solely the BER literature. Asshoff and Hammann (2008) analyzed systematically papers published in the European Researchers in Didactics of Biology [ERIDOB] proceedings of the first five ERIDOB conferences and compared them with research in biology education published in the International Journal of Science Education (IJSE). The authors categorized the articles into the nine categories (1) teacher education; (2) teaching; (3) learning-students' conceptions; (4) learning-classroom contexts; (5) goals, policy and curriculum; (6) culture, social and gender issues; (7) history, philosophy, epistemology and the nature of science; (8) educational technology; and (9) informal learning. The findings showed that the ERIDOB publications focused on the category 'learning', whereas publications in IJSE were more balanced across the nine categories. This major difference between ERIDOB papers and papers published in IJSE is somewhat understandable as the nature of conference presentations and the journal articles are sometimes quite varies. Journals are aiming more international readers while conferences are aimed much more sharing of recent studies among the participants. On the other hand conference participants are mostly limited to the local researchers while international journals are open to worldwide. Therefore their trends in many cases are different than conference proceedings. In addition, English speaking countries contributed most articles to IJSE, and contributions from Europe, apart from the UK, were marginal.

Dirks (2011) examined the contributions of undergraduate BER from the last two decades (1990 to 2010) and focused on many sub-disciplines of biology: microbiology, neurobiology, genetics, genomics, cell and molecular biology, ecology, evolution, and physiology. In addition, three main categories were used to organize BER studies (Student learning or performance; Student attitudes and beliefs; and Concept inventories and validated instruments) and as a result, this research of BER studies revealed many exciting and relatively new areas of research in three main areas. The findings also indicated that most of the studies analyzed were quasi-experiments and studies were structured with control or comparison groups, but lacking complete randomization. Most common references were to those implementing “cooperative” or “constructivist” approaches, particularly studies about active learning. Studies about students’ beliefs related to learning biology or their attitudes about how they perceive or experience certain phenomena often involved interviews where the interview was transcribed and subsequently analyzed. Study characteristics for concept inventories and validated instruments included the year in which the tool was developed, the content area for which the tool was made, and whether or not the tool had been tested for reliability and validity. Finally, the findings indicated gaps in BER, particularly in areas investigating the affective domains of student learning in biology.

In addition, DeHaan (2011) reviewed the BER and scrutinized how teaching and learning of the emerging sub-disciplines of biology developed historically at the higher education level, primarily in the United States. According to the findings obtained, BER began early in the century with sporadic investigations. These were performed largely by science educators in colleges of education, and focused primarily on efforts to improve teaching in high schools and introductory college biology courses.

Umdu-Topsakal, Çalık & Çavuş (2012) carried out a content analysis study in Turkey to determine the trends thesis carried out in BER. Total of 138 graduate theses were analyzed in terms of year, research interest, research methodology and sample. The results indicated that descriptive studies and survey for research methodology are highly dominant. Also, even though learning involved an interaction amongst student, teacher, parent and administrator, there was no study on investigating what the student parents think about their learning responsibility.

More recently in a comprehensive analysis Gul & Sozbilir (2015) reported a content analysis of 633 BER papers published by Turkish science educators in national and international journals. The findings indicated learning, teaching and attitudes were in the forefront as the frequently investigated subjects. Quantitative research was mostly preferred. Besides, commonly used data collection tools included; achievement tests, questionnaires and attitude scales and the commonly used data analysis and presentation techniques were frequency/percentage tables, central tendency measures, t-tests and ANOVA/ANCOVA analyses.

Apart from above studies, there are few researches determining trends in biology education, most of which focused on environmental education (Erdogan, Marcinkowsky & Ok, 2009; Erdogan, Uşak & Bahar, 2013; Ünlü, Sever & Akpınar, 2011).

Together with the increasing attention and rise in the number of research regarding BER the necessity to analyze the trends and emerging sub-fields in BER appears. The information provided by studies towards research trends should be updated for the research community via content analysis which provides an additional method for helping to appraise existing literature in a field and for helping with the strategic appraisal of projected new work (Falkingham & Revees, 1998). In this perspective, Gilbert, De Jong, Justi, Treagust and Van Driel (2003) and Teo, Goh and Yeo (2014) stated that a suitable range (research topics, methods, methodologies, research participants etc.) of research types must be carried out. Therefore, this paper was reviewed publications in BER to indicate recent trends in major journals publishing BER.

This paper provides a descriptive content analysis of studies in BER that were published between the years 1997-2014. This study is valuable and different from previous studies (Asshoff & Hammann, 2008; DeHaan, 2011; Dirks, 2011; Gul & Sozbilir, 2015; Lock, 2010) in four aspects. First, the present study indicates more in detail evolution of BER and trends identified in previous studies (Erdogan et al., 2009; Lock, 2010; Ünlü et al., 2011) especially in terms of specific biology topics. Secondly, this study was scrutinized the BER papers in terms of different variables unlike similar researches. Third, this research was analyzed the publications in terms of all biology topics, while previously studies were emphasized on science education trends with an interdisciplinary approach (Chang, Chang & Tseng, 2010; De Jong, 2007; Lee et al., 2009; Schram, 2014; Sozbilir, Kutu & Yasar, 2012; Tsai & Wen, 2005). Fourth, this study provides a systematic review to cover recent trends through analyzing the papers published up to 2014.

Purpose and the research questions

This paper intends to investigate the research trends of BER papers published in international science education journals listed in Social Science Citation Index [SSCI] of Thomson Reuters® from 1997 to 2014. This broad aim has been divided into sub-questions outlined below to make is searchable pieces. Therefore this study particularly seeks answers to the following research questions:

1. What topics in BER are frequently investigated by science educators?
2. What subject matters in BER are frequently investigated by science educators?
3. What research designs/methods in BER are frequently used by science educators?
4. What data collection tools in BER are frequently used by science educators?
5. What samples and sample sizes in BER are frequently used by science educators?
6. What data analyses methods in BER are frequently used by science educators?

METHODOLOGY

This is a descriptive content analysis study. The content analysis can, in general, be grouped under three sub-headings "meta-analysis, meta-synthesis (thematic content analysis) and descriptive content analysis". In descriptive content analysis, independent qualitative and quantitative studies are reviewed to identify and describe the general trends and research results in a particular research discipline (Çalık & Sözbilir, 2014).

Data collection tool and analysis process

Paper Classification Form [PCF], which was originally developed by Sozbilir et al. (2012), was utilized in this research in order to classify the BER papers. The form previously was revised in a way that it included all of the biology education researches. In revising the PCF, the classification of biology topics presented in Reece et al. (2013) were taken into account and also some small modifications were made by the researchers.

PCF is composed of seven sections as; descriptive information for the identification of a paper, topics, subject matter, method, data collection tools, sample, sample sizes and data analysis methods. The paper classification form was given in Appendix 1.

The papers subject to the content analysis were only those identified as "articles" in the SSCI. The publications such as "editorial", "book reviews" "commentary", "responses" and "letters" were all excluded from this analysis. In addition, because of the varieties of journals publishing science education research papers, authors decided to limit the journals only with seven major science education journals (International Journal of Science Education [IJSE], Journal of Research in Science Teaching [JRST], Journal of Science Education and Technology [JSET], Research in Science Education [RISE], Research in Science & Technological Education [RSTE], Science Education [SE], and Studies in Science Education [SSE]) indexed in Thomson Reuters Science/Social Science Citation Index (SSCI) and Journal of Biology Education [JBE] as it is the only BER journal. All issues of these journals searched through their web pages and articles were selected covering BER between 1997and 2014. By this way, a total of 1376 research papers were identified. All of the papers were downloaded and subject to the content analysis.

During initial stages of the content analysis both authors were y worked together in order to set the reliability of the content analysis. 70 research papers (approx. 5%) were randomly chosen and content analysis performed independently. Then, the analysis was compared, inconsistencies determined and differences were resolved by discussion. After that, the first author analyzed the rest of the papers under the leadership of the second author.

After completing the content analysis, all data transferred to a data base. The data obtained from the database were transferred to Microsoft Excel for the final check for mistakes and then, data were analyzed by using SPSS 20.0. The results were descriptively presented in charts, percentages and frequencies tables.

RESULTS

The findings from Table 1 display the majority of BER papers were published in JBE (31.3%) and IJSE (24.0%) respectively.

Frequently investigated biology topics

As can be seen from Table 2, the most frequently investigated research topics were 'Environment and ecology (21.7%)', followed by 'Genetics and biotechnology (16.5%)' and 'Animal form and function (10.5%)' respectively. Moreover, a significant percentage of papers (17.0%) were published in other topics such as development of scales, biology teachers training studies that has no biology content but related to biology education, concept analysis etc. The least published research topics were 'Plant form and function (3.0%)' and 'The chemistry of life (0.6%)'.

In addition, Table 3 indicates the frequently investigated subject matters. As can

Table 1. The number of the BER papers in journals included in content analysis (all 1997–2014)

Journal	f	%
JBE	430	31.3
IJSE	330	24.0
JRST	153	11.1
SE	148	10.8
JSET	138	10.0
RISE	135	9.8
RSTE	37	2.7
SSE	5	0.4
Total	1376	100

Table 2. Frequently investigated biology topics by researchers

Biology Topics	f	%
Environment and ecology	299	21.7
Genetics and biotechnology	227	16.5
Animal form and function	145	10.5
The evolutionary history of biological diversity	123	8.9
Mechanisms of evolution	116	8.4
The cell	92	6.7
Mixed	91	6.6
Plant form and function	41	3.0
The chemistry of life	8	0.6
Others	234	17.0
Total	1376	100

Table 3. Frequently investigated subject matters in BER

Subject Matters	f	%
Learning	290	21.1
Teaching	258	18.8
Attitude/perception/self-efficacy etc.	236	17.2
Computer-aided instruction	119	8.6
Studies on teaching materials	116	8.4
Nature of science	101	7.3
Curriculum studies	56	4.1
Other subjects	55	4.0
Applied practical studies	54	3.9
Teacher training	38	2.8
Concept analysis	22	1.6
Test/scale development or translation	18	1.3
General educational problems	9	0.7
Research methods studies	4	0.3
Total	1376	100

Table 4. The distribution of the contents of publications examined in four main subjects according to sub-categories (N=687)

Contents of Publications		f	%
Learning*		290	21.08
	Misconception	96	33.1
	Learning styles	13	4.5
	Determining of achievement/knowledge	166	57.2
	Other	18	6.2
Teaching*		258	18.8
	Method comparing	110	42.6
	Effect of teaching on attitude	78	30.2
	Effect of teaching on achievement	180	69.8
	Effect of teaching on scientific process skills	41	15.9
Teacher training*		38	2.76
	Pre-service teacher training	10	26.3
	In-service training	15	39.5
	Other	14	36.8
Nature of science*		101	7.34
	Scientific process skills	22	21.8
	Scientific literacy	42	41.6
	Attitude towards science	28	27.7
	Science in daily life	21	20.8

**Some of the subject matters are marked more than one sub-subject. Therefore the total may exceed total of 687.*

be seen from Table 3, there are the top three subject matters that dominates about 57% of all studies. These studies focus on learning (21.1%), teaching (18.8%) and attitudes, perceptions, opinions etc. (17.2%).

Frequently investigated subject matters

However, Table 3 displays that there are very few studies in the subject matters of curriculum studies (4.1%), applied practical studies (3.9%), teacher training (2.8%), concept analysis (1.6%), test/scale development or translation (1.3%), general educational problems (0.7%) and research methods studies (0.3%). Table 3 also displays there are other subject matters such as computer-aided instruction, studies on teaching materials, nature of science, curriculum studies and other subjects, ranging from 8.6 to 4.0 percent respectively.

To provide deeper insights into the subjects maters used in these papers, this study further examined the learning, teaching, teaching training and nature of science subjects in terms of their sub-categories. As can be seen from Table 4, when subjects matters connected with the learning, teaching, teaching training and nature of science are investigated in detail. It seems that the learning studies focus on identification of misconceptions (33.1%) and determination of achievement/knowledge level (57.2%), while teaching studies focus on method comparing (42.6%), effect of teaching on achievement (69.8%) and effect of teaching on attitude (30.2%). In addition, Table 4 indicates that teaching training studies focus on in-service training (39.5%) while the studies regarding nature of science focus on scientific literacy (41.6%) and attitude towards science (27.7%).

Frequently used research design/methods

As can be seen from Table 5, it has been found out that qualitative papers have a significant percentage (~53%) in total number of papers published. This was followed by quantitative research papers (~43%) and only a small amount of papers (4.2%) employed mixed research designs as research approach. On the other hand, the biology education researchers demonstrate still more interest in qualitative and quantitative research designs while mixed research design shows slowly increasing trend (Figure 1).

When research papers connected with qualitative research designs are investigated in detail, it seems that interactive qualitative research designs were

Table 5. Frequently used research design/methods by researchers

	Research Design	Research Methods	f	%
QUANTITATIVE	Experimental	Quasi experimental	125	9.1
		Pre-experimental	38	2.8
		True-experimental	9	0.6
		Single subject	0	0
		Sub-total	172	12.5
	Non-experimental	Simple descriptive	156	11.3
		Longitudinal	12	0.9
		Cross age/section	29	2.1
		Survey	115	8.4
		Comparative	111	8.1
		Correlational	30	2.2
		Secondary data analysis	3	0.2
		Ex-post facto	0	0
		Sub-total	415	30.2
QUALITATIVE	Interactive	Descriptive	245	17.8
		Case study	230	16.7
		Action research	22	1.6
		Ethnographic study	15	1.1
		Phenomenographic study	15	1.1
		Grounded theory	12	0.9
		Critical studies	5	0.3
		Hermeneutic	2	0.1
		Others	16	1.2
		Sub-total	561	40.8
	Non-Interactive	Review	52	3.8
		Content analysis	47	3.4
		Concept analysis	39	2.8
		Historical analysis	2	0.1
		Meta-synthesis/analysis	1	0.1
		Others	29	2.1
		Sub-total	170	12.3
MIXED	Mixed	Triangulation (Quan + Qual)	44	3.2
		Explanatory (Quan to Qual)	11	0.8
		Exploratory (Qual to Quan)	3	0.2
		Sub-total	58	4.2
		Total	1376	100

mostly preferred (40.8%). It has also been found that descriptive research method

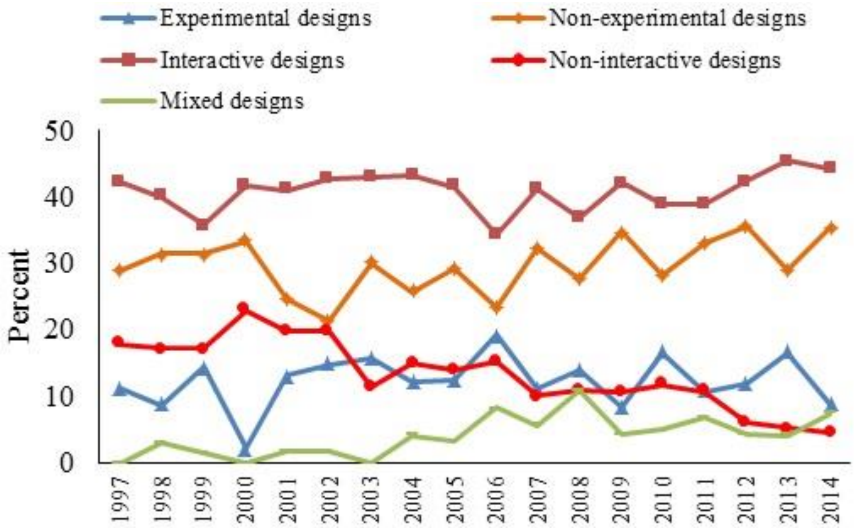

Figure 1. Trends in research designs across years (1997-2014)

(17.8%) and case study (16.7%) are among the most preferred methods of all interactive qualitative research designs. Other interactive methods as ethnographic study, phenomenographic study, grounded theory, action research etc. have used very little. Among non-interactive research designs, reviews (3.8%), content analysis (3.4%) and concept analysis (2.8%) methods are observed to be the most preferred methods. Other non-interactive methods as historical analysis and meta-synthesis/analysis etc. have been used very little.

Similarly, investigating quantitative research designs in detail, it seems that non-experimental research designs (30.2%) have been mostly preferred and experimental designs have less percentage (12.5%) than non-experimental research designs. With respect to non-experimental research designs, it has been found that simple descriptive (11.3%), survey (8.4%) and comparative research methods (8.1%) are the most preferred methods. However, it also has been found that there were few correlational and secondary data analysis study and no ex-post facto studies. In addition, present study has revealed that the most commonly used experimental research design is the quasi-experimental (9.1 %) with few pre-experimental (2.8%) and true-experimental research methods (0.6 %). Besides, it was found out that there was no single subject research method used.

In addition, the percentage of the mixed studies (4.2%) were considerably lower than quantitative and qualitative methods. However, the use of triangulation method within mixed research methods was dominant (3.2%). Previously researches similarly showed use of mixed methods as quite uncommon (Çiltaş, Güler & Sözbilir, 2012, Göktaş, Hasançebi et al., 2012; Sozbilir et al., 2012).

Figure 1 displays the trends in biology education researches in terms of research designs across the years. As seen from Figure 1, the interactive designs are the major type of research designs from 1997 to 2014. This is followed by non-experimental designs. In addition, for all years, mixed researches were least preferred designs. Figure 1 also displays that all these research designs do not show major change over the years although there were small fluctuations such as non-interactive qualitative designs are slightly decreasing while non-experimental quantitative designs are slightly increasing.

Frequently used data collection tools

According to Table 6, questionnaires (34.7%), interviews (33.4%) and documents (29.4%) are used most often as the data collection tools. They are

Table 6. Frequently used data collection tools in biology education researches

Type of data collection tools	f	%
Questionnaires*	477	34.7
Open-ended	156	11.3
Likert type	273	19.8
Multiple choice	29	2.1
Others	71	5.2
Achievement tests*	279	20.3
Multiple choice	164	11.9
Open-ended	100	7.3
Others	53	3.9
Aptitude, attitude, perception, personality etc. tests	109	7.9
Interviews*	459	33.4
Semi-structured	276	20.1
Structured	87	6.3
Unstructured	66	4.8
Focus group interviews	36	2.6
Observations	258	18.8
Non-participant observation	193	14.0
Participant observation	66	4.8
Alternative assessment tools	122	8.9
Documents	405	29.4
Others	62	4.5

* *Some of the data collection tools are marked more than one sub-instrument*

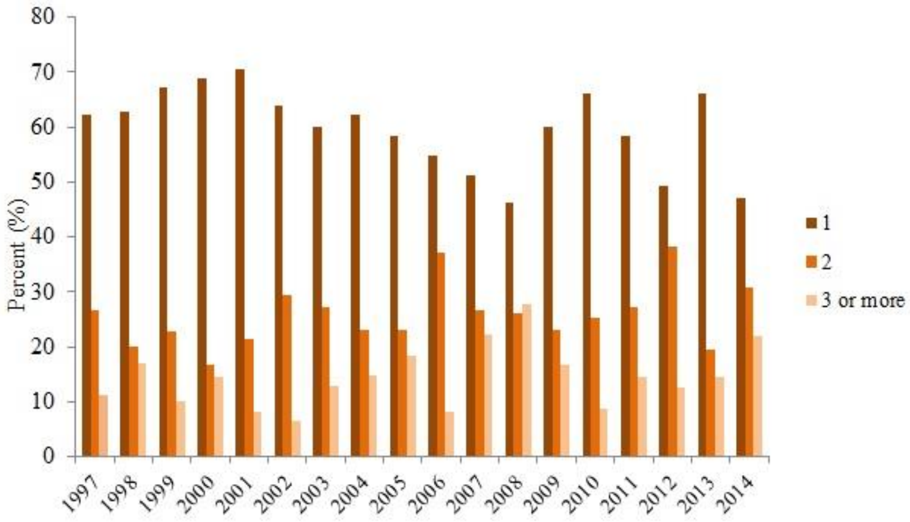

Figure 2. Number of different data collection tools used across years (1997-2014)

followed by achievement tests (20.3%) and observations (18.8%). In addition, aptitude, attitude, perception etc. tests (7.9%) and alternative assessment tools (8.9%) were rarely used and others (4.5%) were the least preferred tools.

As seen from Table 6, the most commonly used types of questionnaire were Likert-type (19.8%) and open-ended questionnaires (11.3%). However, the most commonly preferred achievement tests were multiple choice tests (11.9%). In addition, semi-structured interviews (20.1%), non-participant observations (14.0%) and documents (29.4%) were used the most in the especially qualitative studies.

The following figure presents the number of the different data collection tools across the years. The findings obtained displays one data collection tool (59.2%) is widely used in total and this is followed by two data collection tools (26.2%) and three or more data collection tools (14.5%) respectively. Similarly, as seen in Figure 2, it is clear that one data collection tool is used more commonly across years. Nevertheless, although a small number of one data collection tools showed a decline in recent years, it was still the most popular as frequency of use. However, there is a slight increase in number of two and three or more data collection tools in recent years.

Table 7. Frequently studied samples

	f	%
Secondary (9-12)	459	33.6
Undergraduate	312	22.7
Primary (1-8)	277	20.1
Educators	243	17.7
Postgraduate	18	1.3
Parents	11	0.8
Pre-school	10	0.7
Administrators	8	0.6
Others	41	3.0
Not-reported	201	14.6

**Some of the papers are marked more than one sample type*

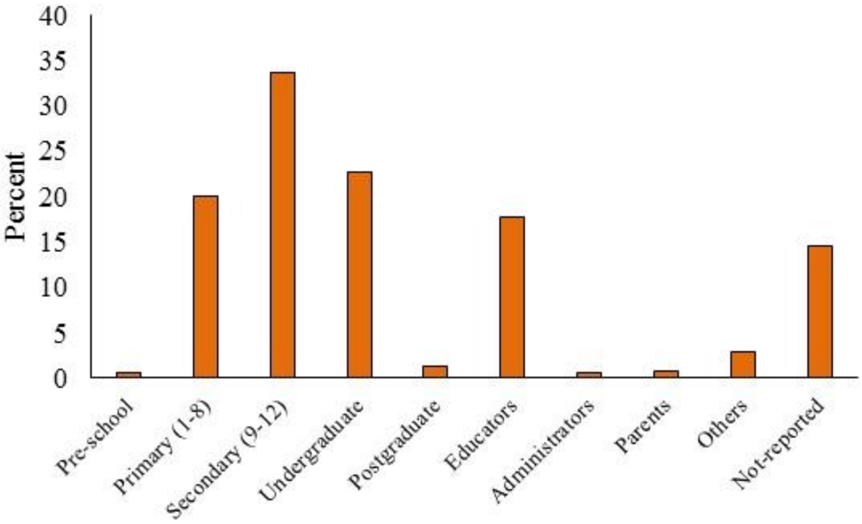

Figure 3. Frequently studied samples

Frequently studied samples and sample sizes

Table 7 and Figure 3 displays the sample/populations chosen for the research subjects. Mostly secondary school students (33.6%) and undergraduate students (22.7%) were chosen as sample groups. These were followed by primary school students (20.1%) and educators (17.7%). And also, studies of not-reported samples had remarkable share (14.6%). The rest of sample populations were preferred least often.

According to the findings from Figure 4, the main sampling range used in the biology education research papers was 31-100 samples (22.7%), which are followed by 101-300 samples (20.3%) and 11-30 samples (16.1%) respectively. According to the results of the present study, the number of research papers conducted with the participation of more than 1000 samples is (4.9%) lower than the others.

Frequently used data analysis methods

The findings indicated that, for all years from 1997 to 2014, qualitative data analysis methods (60.8%) were used commonly. This analysis methods were followed by quantitative descriptive analyses (55.3%) and quantitative inferential analysis methods were found to be the least preferred analysis methods (41.2%) in general. In addition, Figure 5 displays the findings on the frequently used data analysis methods across years. According to the findings from Figure 5, a sharp increase in the number of used data analysis methods was not observed in the period of 1997–2014. However, although the interests to qualitative analysis methods have become slightly declined in recent years, there was a slightly increase in inferential and quantitative descriptive analysis methods in the same years.

Following figure lists findings on more detailed explanation of the frequently used data analysis methods. As can be seen from Figure 6, the most preferred

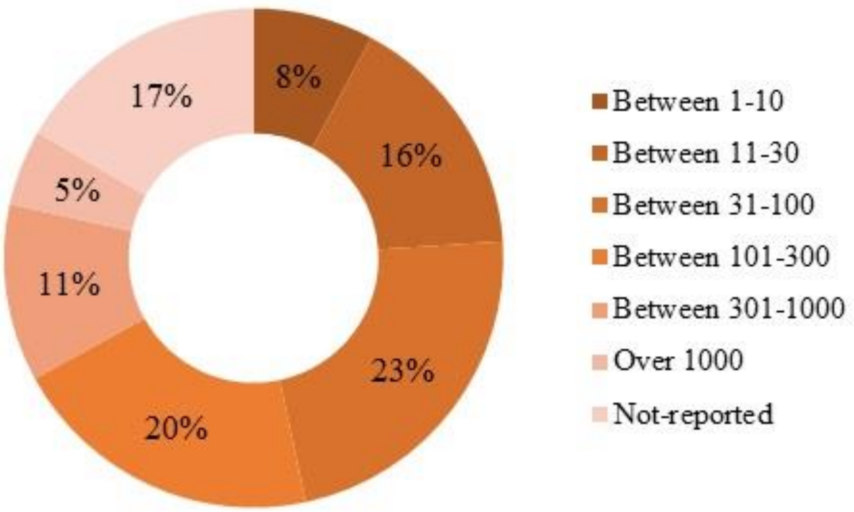

Figure 4. Frequently studied sample sizes

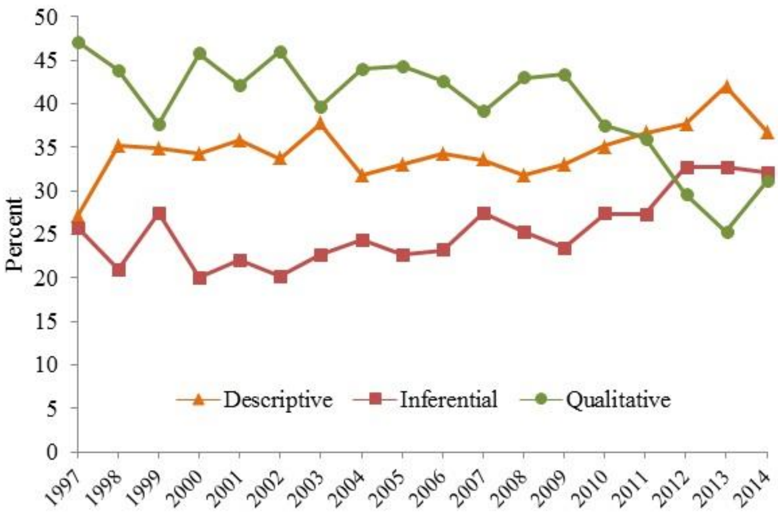

Figure 5. Trends in frequently used data analysis methods

analysis methods are quantitative descriptive analyses methods such as f/% tables (31.4%), central tendency measures (26.7%) and charts (28.6%). This methods have been followed qualitative descriptive (19.3%) and content analysis (22.4%). In addition, it has been found that t-tests (15.6%) and ANOVA/ANCOVA analysis methods (15.8%) and non-parametric tests (11.8%) were commonly preferred by science educators. It have been also found that advanced statistical methods such as MANOVA/MANCOVA tests (2.3%), factor analysis (3.1%), and regression analysis (4.7%) have been used the least.

In addition to above findings, Figure 7 indicated that single data analysis methods (50.8%) were used in the majority of studies and this were followed by two data analysis (36.8%). On the other hand, few researchers preferred using three or more data analysis method (12.4%) frequently.

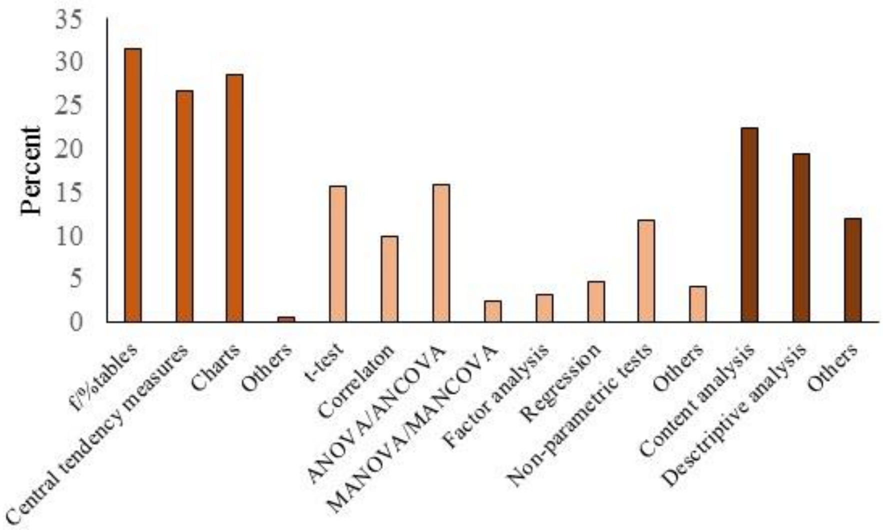

Figure 6. Frequently used data analysis methods and techniques

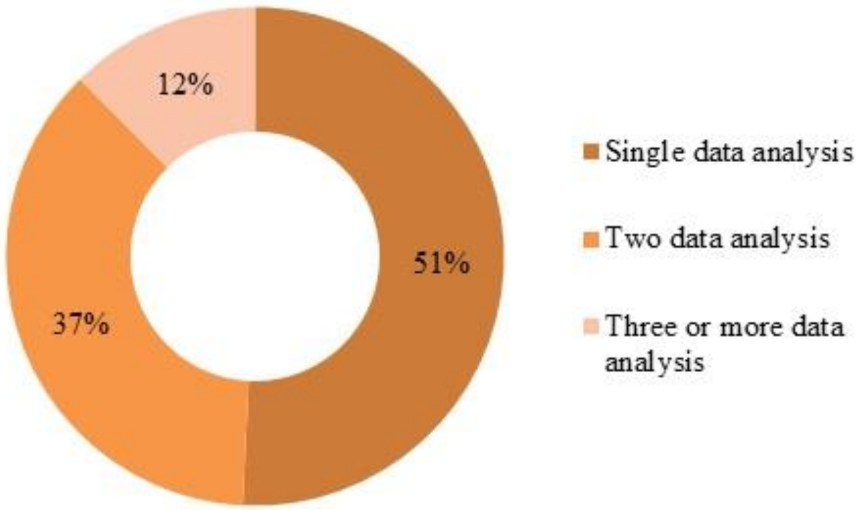

Figure 7. Number of different data analysis methods combined in a study

DISCUSSION AND CONCLUSION

There have been significant developments in the subject matters studied and methodology for doing research in science education area and in the sophistication of the questions being investigated in the world (Sozbilir & Kutu, 2008). Present research trend analysis aimed at providing an overview to young researchers in the field of biology education research.

This study revealed that most of the papers were published in JBE and IJSE. The high number of papers in these two journals is usual because JBE focuses on only the field of biology education and also, the number of the publication/volume of IJSE in a year is more than the others.

The findings from content analysis showed that the "environment and ecology", "genetics and biotechnology" and "animal form and function" was the most popular research topics. Environment and ecology is an interdisciplinary topic studied by different researchers not only biology educators. Therefore, more papers may have been published in topic of environment and ecology. However, worldwide studies (Çimer, 2012; Fonseca, Costa, Lencastre, & Tavares, 2012; Reiss & Tunnicliffe, 2001; Usak, Erdogan, Prokop & Ozel, 2009; Yeşilyurt & Gül, 2012) have revealed that students, prospective teachers or teachers still have limited knowledge, learning difficulties, misconceptions, negative attitudes etc. on topics of genetics and biotechnology and animal form and functions (including nutrition, circulation and gas exchange, the immune system, osmoregulation and excretion, hormones and the endocrine system, animal reproduction, nervous systems, sensory and motor mechanism). This may cause that researchers have done more studies on these topics. In addition, one of the frequently studied major topics is research papers classified as others, which aren't directly related to biology topics and conducted on different topics such as test/scale development, general educational problems, concept analysis etc. The current study also shows that topics such as "plant form and function" and "the chemistry of life" have gained less attention. In literature, plant form and function have not generally been cited as one of difficult topics to be learned. And also, because of the fact that some important biology topics (such as photosynthesis) regarding with the plants were addressed under different headings in this study, less papers may have been published in the topic of plant form and function. However, more related to chemistry, biology researchers may have done fewer studies in the chemistry of life.

Analysis of the papers showed that the top three research topics in the BER were learning, teaching and attitude/perception/self-efficacy etc. respectively. Moreover, determination of achievement level and misconceptions on the basis of learning, effects of teaching on achievement and attitude and method comparing on the basis of teaching, in-service training on the basis of teacher training and scientific literacy on the basis of nature of science were studied commonly. This result is more or less similar to other science education trend studies throughout the world (Chang et al., 2010; Lee et al., 2009; Sozbilir et al., 2012; Tsai & Wen, 2005). However, Table 3 indicates the lack of studies focusing on applied practical studies, curriculum studies, teacher training, concept analysis, test/scale development or translation, general educational problems, research methods studies. In this sense, it may be recommended that these research subjects should be given more importance. Regarding the research design/methods, it was found out that the majority of the studies employed qualitative and most of the remaining studies were quantitative research tradition. Papers employed mixed method as a research approach were very limited. Because of the fact that qualitative researches are generally used to discover themes and relationships at the case level, and plays a discovery role, qualitative research may present more fundamental ideas about contemporary issues, and is better recognized by others in related fields (Lee et al., 2009). Due to these advantages, it can be said that the qualitative research designs have an important effect in the field of biology education. However, a good qualitative study isn't easy to produce because, unlike quantitative studies, with its established steps to follow, the unique situations of qualitative studies require judgment decisions that inexperienced researchers may not be able to make properly (Harry, Sturges, & Klinger, 2005). Moreover, interpretation of qualitative results is especially challenging to new researchers (Sozbilir et al., 2012). Therefore, this finding is a satisfactory situation in terms of this research.

Regarding the qualitative research designs, interactive researches (this category also has the highest overall percentage) especially as descriptive researches and case studies were preferred by researchers. As stated by Gerring (2004), this maybe is due to the fact that case studies are more useful for forming descriptive inferences, all other things being equal. Similar conclusions were reported by other researchers (Selçuk, Palancı, Kandemir & Dündar, 2014; Sozbilir et al., 2012; Umdu-Topsakal et al., 2012). In addition, despite the fact that non-interactive qualitative research designs were less popular, non-interactive researches such as review, content analysis and concept analysis has been more frequently used in recent years. Sozbilir et al. (2012) stated that especially concept analyses studies are those describing and discussing the different meanings and appropriate use of the educational and scientific concepts. These studies do not require the collection of experimental data and are mostly written on the basis of the researchers' knowledge and experience. It is also common to use documents as data collection tools in this method. Nevertheless, some interactive and non-interactive qualitative research designs as ethnographic study, phenomenographic study, grounded theory, action research, historical analysis, meta-synthesis/analysis etc and mixed research designs were not frequently used. This finding may be connected with biology educators' knowledge, skills and attitudes towards these types of qualitative research and mixed research designs. Therefore, it can be suggested that there is a need to develop biology educators. Similarly, Umdu-Topsakal et al. (2012), studying the trends of Turkish biology education, also suggest that researchers should study on some qualitative research methods such as phenomenography and action research to get a deeper focus on related research interest.

When the quantitative research methods used in the researches were examined, it was found that non-experimental research designs have been mostly preferred than experimental designs. As known, an experimental design was defined as a study that entails manipulation of an instruction-related independent variable and has random assignment of students, schools, or classes to the different levels or categories of the manipulated variable, thus constituting at least one experimental group and at least one comparison/control group (Minner, Levy & Century, 2010). Therefore, as stated McMillan and Schumacher (2010), the reason for less use of the experimental designs is likely because designing experimental studies is difficult and time-consuming, requiring creating the experimental and control group, complexity of data analysis etc. Other findings reported in the literature support this result (Minner et al., 2010). Regarding with experimental research design, quasi-experimental was the most popular. A quasi-experimental design entails manipulation of an instruction-related independent variable, and a comparison/control group is present, but randomization is absent at all levels. This advantage of quasi-experimental design may causes mostly to be preferred. For the non-experimental quantitative methods, descriptive, surveys and comparative research methods were the most common. The reason for which descriptive and surveys were mostly used, as stated by Umdu-Topsakal et al. (2012), was probably that most of the biologists have attempted to learn what biology education meant and what research areas were available. This may have increased to use the these types methods. In this study, it was also found that secondary data analysis was very few and there is no studies that identified as using ex-post facto. In a parallel with this finding, some researchers (Göktaş, Hasançebi et al., 2012; Sozbilir et al., 2012; Umdu-Topsakal et al., 2012) found that some non-experimental research methods (i.e. secondary data analysis and ex-post facto) are either rarely observed or not used. This deficiency require that most of the biology educators have changed their research interests into these types of research methods.

Although the percentage is relatively low compared to qualitative and quantitative approaches mixed methods designs are gaining slight attention in BER papers. This tendency is in parallel with the other studies findings. For instance, Schram (2014) stated that more and more researchers in science education have been turning to the practice of combining qualitative and quantitative designs in the same study in recent years. Mixed methods designs have a potential to develop BER studies further as they bring together two major paradigms, quantitative and qualitative. This is a tendency that seems to be increasing in the following years in science education researches. Therefore, it could be suggested for the science education researchers to learn how to combine quantitative and qualitative approaches effectively to develop solution to the biology education.

This study revealed that most of the published papers were utilized from Likert type and open-ended questionnaires, semi-structured interviews and documents (Table 6) and also most studies, as seen from Figure 2, are based on data collected through only one or two different data collection tools. Nevertheless, in recent years it is observed that especially one data collection tools have been decreasing, but increasing gradually two and three or more data collection tools. The reason for all these findings may be due to the fact that the researchers preferred often qualitative research designs/methods. The use of Likert-type questionnaires are the most common amongst the data collection tools used throughout the world (Sozbilir et al., 2012). Especially due to facilities in analyzing and application of the data, questionnaires might orientate researchers to use questionnaires in their studies. Moreover De Joung (2007) stated the use of these instruments was often quite fast and many data could be collected easily. However, data analysis could not provide much information about the argumentation that was used by the participants. This kind of information could better be collected by using different way such as multiple-choice questions providing participants to explicate their answers, and essay questions of an open or a semi-structured nature (De Jong, 2007). Similarly, open-ended questions can provide richer data (Lock, 2010).

On the other hand, observations (especially non-participant observation), were among frequently used data collection tools. In parallel of the findings above, because of the fact that most of the research papers were preferred qualitative research designs/methods, and also the qualitative research takes place in natural settings and is interpreted in a holistic way (Çiltaş et al., 2012), observations may have been used widely.

In this research, it found out that multiple choice achievement tests are widely used unlike alternative assessment tools. It may be due to that multiple choice achievement tests are easier to prepare, apply and score rather than the alternative assessment tests (such as two/three tier diagnostic tests, concept maps, portfolios etc.).

Another finding from this research was that aptitude, attitude, perception, personality etc. tests were not used widely. This may probably stems from these types of tests were used in quantitative researches mostly.

When sample populations were examined, secondary school students were the most preferred sample groups and this was followed by undergraduate and primary school students, and educators respectively. This finding is consistent with the findings of studies by Çiltaş et al. (2012), Göktaş, Hasançebi et al. (2012), Sozbilir et al.

(2012). Such a sampling trend may come from the idea that researchers have tend to conduct studies with samples being reached easily because biology-based topics at secondary schools and undergraduate are presented as more comprehensive and more detailed. And also, researchers probably accessed these sample populations because they were most suited to the types of inquiry being conducted (Göktaş, Küçük et al., 2012).

Regarding the frequently studied sample sizes, it was found that 31-100, 101-300 and 11-30 samples respectively were used frequently. The reason for this finding, as stated McMillan and Schumacher (2010), of particular concern is the impact of having a small sample in studies that show no statistically differences or relationships, especially because so many educational studies employ relatively small samples. However, whenever there is small sample, other factors have a greater likelihood of influencing the results, such as bias in the sample or the presence of confounding variables.

This research also includes the data analysis methods used in the published papers. It was found that descriptive and inferential analysis were used in quantitative researches, while descriptive analysis and content analysis were used in qualitative researches. However, the rate of qualitative data analyses were highest across years and use of inferential data analysis methods are of the second order. The reason for this is most likely that researchers prefer qualitative research designs/methods. But it also is noteworthy for frequency of qualitative data analyses to decrease while descriptive and inferential analysis have been increasing in recent years.

Among descriptive data analysis, f/% tables, central tendency measures and charts were the most common. Being also included in a lot of inferential data analysis, it is usual to be mostly used these types of analysis. Additionally, among inferential data analysis, t tests, ANOVA/ANCOVA and non-parametric tests were commonly used. But, there were few samples of MANOVA/MANCOVA, factor analysis and regression analysis. The reason behind conduct of mainly these analyses may be that studied inter-variable characteristics are designed at low numbers and in an easy-to-explain manner and can be easily interpreted (Selçuk et al., 2014). In addition, the reason for which advanced statistical methods such as MANOVA/MANCOVA tests, factor analysis and regression analysis were less preferred may be connected with lack of researchers' knowledge and skills. And the fact that content analysis was widely used in qualitative researches may be connected with nature of the published qualitative researches.

In addition to above findings, it was founded that single data analysis method were used in majority of studies and this were followed by two data analysis and also few researchers prefer using there or more data analysis method frequently. The reason behind these findings may likely be because of the fact that only mixed methods studies require use of a combination of all three data analysis approaches, its proportion is quite low (Sozbilir et al., 2012).

LIMITATIONS AND FUTURE RESEARCH

It is hoped that this research will help researchers explore the current status of researches and trends in the BER. However, this trend research remains limited in several aspects. For example, it may be suggested that a similar research may be repeated in more comprehensive range of years and included in more journals. Also, future researches can be focused only on biology education journals. In addition, national and international comparisons of research papers in the field of biology education can be made. And also, with comparison of the authors' nationality, in order to identify how much the collaboration is evident between science education researchers. However, it should be considered that this purposeful selection of papers from few education journals does not provide a detailed list of researches in this field. As stated Schram (2014), with the vast number of science journals and the restricted search terminology and time period used, such a claim cannot be made. Nevertheless, this research presents an overview of general tendency of BER. Finally further studies may be focus on much more detailed analysis through meta-synthesis in particular areas of the BER. Through this kind of meta-synthesis researchers may have access to the knowledge how studies in a particular area helps to overcome teaching and learning in BER.

AUTHORS' NOTE

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Appendix 1: Paper classification form

A. INFORMATION ABOUT PAPER

1.Title:

2.Author/s: | **3.Auth.Nation.** a.TR ☐ b.Foreign ☐ c.Mixed ☐

4.Journal Name: | **5.Journal Type:** a.International ☐ National ☐

a.Year: | b.Volume: | c.Issue: | d. Pages: | **6.Language** a.Eng. ☐ b.Turkish ☐ c.Other ☐

7. Indexes: a.SCI/SSCI: ☐ b.ERIC-BEI-EI-AEI: ☐ c. ULAKBİM SBVT ☐ d.No Index ☐ e.Other ☐

B. MAIN DISCIPLINE THAT PAPER BELONGED

☐ 1. Chemist. of life ☐ 2. The cell ☐ 3. Genetics and biotech. ☐ 4. Mech. of evolution ☐ 5. Biodiversity

☐ 6. Plant form and func ☐ 7. Animal form and func ☐ 8. Environment and Echology ☐ 9. General biology ☐ 10. Other

C. SUBJECT OF THE PAPER

1. ☐ Learning
   O Mis O LS O Ach. O Other
2. ☐ Teaching
   O MC O Att. O Ach. O SPS
3. ☐ Teacher training
   O PTE O IT O Other
4. ☐ Study on teaching materials
5. ☐ Computer-aided teaching
6. ☐ General educational probl.
7. ☐ Concept analysis
8. ☐ Attitude, perception research
9. ☐ Curriculum studies
10. ☐ Test, scale development or translation
11. ☐ Research methods studies
12. ☐ Nature of science
    O SPS O SL O ATS O SiEL
13. ☐ Other.................................

D. RESEARCH METHODS/DESIGNS

QUANTITATIVE

1. **Experimental**
   - 11. ☐ True-experimen.
   - 12. ☐ Quasi-experim.
   - 13. ☐ Pre-Experimen.
   - 14. ☐ Single subject
2. **Non-Experimental**
   - 21. ☐ Descriptive
     - O Longitudinal
     - O Cross-age/sect.
   - 22. ☐ Comparative
   - 23. ☐ Correlational
   - 24. ☐ Survey
   - 25. ☐ Ex-post facto
   - 26. ☐ Sec. Data analy.

QUALITATIVE

3. **Interactive**
   - 31. ☐ Etnography
   - 32. ☐ Phenomenography
   - 33. ☐ Case study
   - 34. ☐ Grounded theory
   - 35. ☐ Critical studies
   - 36. ☐ Descriptive
   - 37. ☐ Other ....
4. **Non-Interactive**
   - 41. ☐ Historical analy.
   - 42. ☐ Concept analy.
   - 43. ☐ Review
   - 44. ☐ Metasynthesis
   - 45. ☐ Other ....

MIXED

5. **Mixed**
   - 51. ☐ Explanatory (QuanèQual)
   - 52. ☐ Exploratory (QualèQuan)
   - 53. ☐ Triangulation (Quan+Qual)

E. DATA COLLECTION TOOLS

1. ☐ Questionnaire
   O Open-end. O Mulp. choice O Likert O Other
2. ☐ Achievement test
   O Open-end. O Mulp. choice O Other
3. ☐ Aptitude, attitude, perception, personality etc. tests
   Please write the title ....
4. ☐ Interview ....
   O Structured O Semi-Str O Unstructure. O Focus G
5. ☐ Observation
   O Participant O Non-participant
6. ☐ Alternative assessment tools
   (Diagnostic tests, concept map., portfolio etc.)
7. ☐ Documents
8. ☐ Others (please provide title) ....

F. SAMPLE

a. Sample

1. ☐ Pre-school
2. ☐ Primary (1-5)
3. ☐ Primary (6-8)
4. ☐ Secondary (9-12)
5. ☐ Undergraduate
6. ☐ Post-graduate
7. ☐ Educators
8. ☐ Administratives
9. ☐ Parents
10. ☐ Others ....
11. ☐ Not reported

b. Sample Size

1. ☐ Between 1 to 10
2. ☐ Between 11 to 30
3. ☐ Between 31 to100
4. ☐ Between 101 to 300
5. ☐ Between 301 to 1000
6. ☐ Over 1000
7. ☐ Not reported

G. DATA ANALYSIS

QUANTITATIVE DATA ANALYSIS

1. **Descriptive Statistics**
   - 11. ☐ Frequency/percentage tables
   - 12. ☐ Central tendency measures
   - 13. ☐ Charts
   - 14. ☐ Others......................
2. **Infrential Statistics**
   - 21. ☐ t-test
   - 22. ☐ Correlation
   - 23. ☐ ANOVA/ANCOVA
   - 24. ☐ MANOVA/MANCOVA
   - 25. ☐ Factor analysis
   - 26. ☐ Regression
   - 27. ☐ Non-Parametric tests
   - 28. ☐ Others.......................

QUALITATIVE DATA ANALYSIS

3. **Qualitative Analysis**
   - 31. ☐ Content analysis
   - 32. ☐ Descriptive analysis
   - 33. ☐ Other ....

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