# An Alternative Perspective for Malaysian Engineering Education: A Review from Year 2000-2012

**Kamaleswaran Jayarajah [1], Rohaida Mohd Saat [2], Rose Amnah Abdul Rauf [3]**

[1] drkamal_83@yahoo.com
University of Malaya

[3] rohaida@um.edu.my
University of Malaya

[3] rose_amnah@um.edu.my
University of Malaya

## ABSTRACT

The purpose of this study is to explore the research base of engineering education in the Journal of Engineering Education (JEE) through an analysis review of articles for a 12-year period, from 2000 to 2012. The research base review focuses on identifying five characteristics of engineering education: (a) temporal distribution, (b) frequently cited authors in JEE articles, (c) research areas involved in each article, (d) types of participant, and (e) methodological design employed. Published journals from web-based sources were selected aligned on the original author's discussion of engineering education in the articles. The findings summarize the core consistencies of engineering education literature across the globe over the years by identifying the engineering related content professionals addressed in their respective fields.

**Keywords:** *JEE, Engineering, Education, Review, Issue*

## INTRODUCTION

Engineering is a field not understood by many people ("American Perspective on Engineers and Engineering" 2004; "Harris Poll Reveals Public Perceptions of Engineering" 1998). Since engineering involves a broad spectrum of activities and goals, the public is still unable to see engineering's many aspects and how these aspects interact. The different representations of engineering may continue to cause public misunderstanding (Mean & Diefes-Dux, 2012). The same goes with the students because though students displayed a broadened awareness of engineering than the existing research suggests, there was limited knowledge of various engineering fields and a strong perception of engineering as large construction (English, Dawes, & Hudson, 2011). At the same time, it is perceived that engineering programs often do not provide enough practical experiences early in the curriculum (Shallcross, 2006).

Apart from the misinterpretation and limitations in engineering education, currently the number of engineers produced around the world seems to have decreased in a worrying fashion. In fact the lack of qualified engineers is currently reported to be one of the principal obstacles to economic growth encountered by innovative firms in many industrialized and industrializing countries (UNESCO, 2010). The number of students in the United States (US) who enter engineering programs in college is projected to drop, a trend that many believe will have a negative impact on the US workforce (NAS et al., 2007; NAE & NRC, 2009). In addition, students who do pursue engineering degrees do not reflect the diversity of students in the US, a pattern of enrolment that is likely to have a number of negative consequences, both for the successful practice of engineering and for the resolution of broader societal issues (NAE & NRC, 2009). According to DeJarnette (2012), there is a great need in the US for talented engineers. Parallel with that, Spain also faces a shrinking engineering workforce (Capilla, Hervas, & Soriano, 2008). The percentage of young researchers working in this area has declined, as can be seen when analyzing the results of several research reports (Aceituno, Campanario, & Burgos, 2010; Alemany, Alvarez, Planellas, & Urbano, 2011; INE, 2011; Ministerio de Ciencia e Innovacion, 2008; OECD, 2009). Converging evidence has shown that some countries have taken early measures to prevent a decrease in producing creative engineers. In line with that, China has already encouraged engineering education among primary school students through a project called Total Engineering Education (TEE) (Tu, 2006). TEE encompasses the entire engineering education and profession preparation system, beginning from primary school programs through to high school graduation, to post-secondary and graduate education (Tu, 2006).

Malaysia is also experiencing the same problem as other countries across the globe. In Malaysia, the Ministry of Education has estimated the current number of engineers in the country at about 140,000. This is projected to reach over 200,000 by 2017, based on an annual output of 15,000 new graduates here in Malaysia (Kieong, 2012). These engineers should be academically qualified, have the necessary training and experience or wide exposure to the engineering profession. However, it is an alarming target to be accomplished since the students' enrolment into the science stream has decreased as low as 29% in 2012 (Nordin, 2012). At the present rate, it will be difficult for Malaysia to increase the number of quality engineers in the country. This can result in serious consequence to the country's innovation and development plan since only students who enrol in Science, or Science and Mathematics are able to pursue further in science education and science related careers. It is inevitable that the sustained competitive advantage of nations depend more and more on the engineering field. Unfortunately, Malaysian primary and secondary schools seem to have a limitation in producing enough students with the interest, motivation and skills required (Ali, 2012). This is an urgent issue since Malaysia needs at least 500,000 workforce from the science stream this coming 2020 to be declared a fully developed country (Hamdan, 2012). Apart from the students' interest in learing science, the misconceptions and the restrictions in engineering programs could also be the factors holding back Malaysia's vision to grow into an established nation.

Hence, this paper focuses on the research areas in each of the engineering education article that has been researched in the *Journal of Engineering Education* (JEE) over a period of 12 years. Despite having a high impact factor (1.925), there has been a lack of review research in JEE; this paper reviews published articles in almost the entire journals in JEE. Apart from that, although there are a number of review articles published in JEE, none of them are published for a review of 12 years. Therefore, the search in this paper was limited from the years 2000 until 2012 and a total of 222 published articles were identified.

This review is not undertaken to report solely on the collective achievement of a large number of people regarding engineering education research but rather to be used as a means for setting a comprehensive foundation for the future research and development of Malaysian engineering education. Despite almost all the perceived articles in JEE were authors from abroad, this review provides the thoughts and an eye opener for Malaysian researchers especially on the advancement of Malaysian engineering education. Thus, this review not only represents a synthesis in its own right but at the same time offers crucial perspective from a collective of engineering education research across the globe. This paper aims at giving some serious points and beliefs about engineering education apart from moving forward, in line with other nations.

The purpose of this paper is to give a general idea of engineering education that has been carried out in countries across the globe as well as to assess it and discuss its possibilities for future development of Malaysia. This paper is also aimed at exploring the type and the regularity of research areas that have been researched in engineering education. Apart from analysing the research areas or issues in each engineering field, the type of participants and the research methodology employed are also analysed. In fact, the authors who have published regularly in JEE articles are also discussed in this paper in order to provide an opportunity to Malaysian researchers who are keen in researching engineering education fields. However, it is perceived that some loopholes do exist where more research could be carried out involving engineering education across the nation. This review answers the ambiguities by reflecting on where Malaysian engineering education could be directed apart from perceiving questions that need to be considered in its on-going development.

## METHOD

This paper identified published research using Educational Resources Information Centre (ERIC) as the main scanning bibliographic database. Access to ERIC database has become considerably easier with the emergence of web-based service providers such as EBSCO, Educational Journals @ ProQuest, Emerald, Science Direct, Scopus ™, Springer Link, Taylor and Francis Online and Web of Science. However, this paper has solely employed Educational Journals @ ProQuest database where this database is scanned to retrieve the published articles involving engineering education in JEE articles. These articles were screened using key search terms such as "engineering", "education", "review", "issue" and "field". By analysing the articles' title, abstract, research areas, samples, methods and findings, this paper managed to provide empirical results involving temporal distribution of engineering education, research at education levels and methodological approaches apart from reviewing the frequently cited authors in JEE. Apart from that, this article has grouped the steps that countries have taken in facing the dwindling force of engineering in their respective nations. The methods utilized by the researchers have been grouped and analysed in a comprehensive fashion. These merged groups have been compressed into categories such as learning style, teaching methods and STEM education where these categories or research areas remain as one of the ways to overcome the shrinking force of engineers both in developed and developing countries.

Meta-analysis offers several benefits over traditional narrative review as employed in this paper. Although meta-analysis offers a more objective, disciplined and transparent style to assimilate existing findings, in practice meta-analysis still produces inaccurate conclusions (Ellis, 2011). In fact, editorial boards have discovered that findings must be interpreted in a significant way and not just by providing the effect sizes without providing the viewpoint (Humphrey, 2011). Apart from that, a collection of quantitative data is required for an inclusion of meta-analysis (Ellis, 2011) where this paper has managed to retrieve fewer numbers of published researches which use the quantitative research paradigm. Hence, a narrative review supported by descriptive empirical statistics is employed to interpret the research findings in this paper.

**RESULTS**

The findings of this paper provide a descriptive analysis of the engineering education research field. Although there is a research base for engineering education in Malaysia, these findings give an additional appearance of why and how other countries have perceived engineering education for the past 12 years. Parallel to that, these findings have summarized the scope of research being conducted by engineering education scholars, who is being studied and the institutions in which engineering education research is being conducted and published. The findings are organized in five sections;

a) Temporal distribution,
b) Frequent authors in JEE articles,
c) Research areas involved in each article
d) Types of participant and
e) Methodological design employed.

a) Temporal distribution of research studies in engineering education.

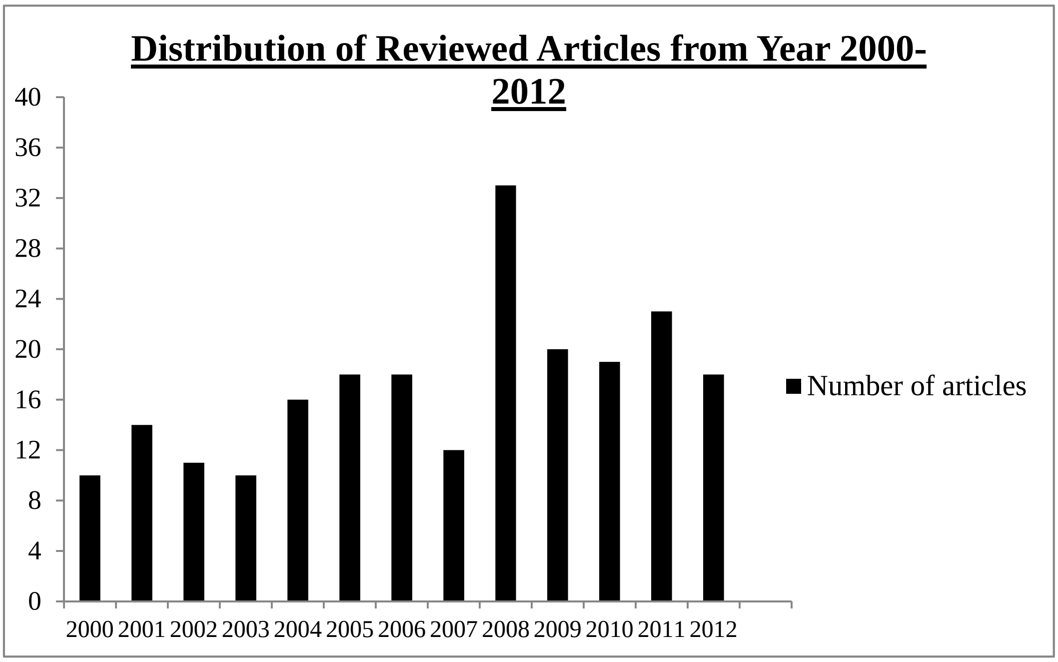


*Figure 1*: Distribution of reviewed articles.

Figure 1 presents the distribution of articles during the studied period. The total number of articles analysed is 222 throughout a period of 12 years. The dispersal of engineering education articles published in JEE fluctuated from 2000 until 2012 whereby the maximum number of reviewed articles was 33 in 2008. However, the distribution of articles portrayed a positive outlook when the reviewed articles increased gradually from 2003 until 2006. The total increment was 80%. The following year, the reviewed articles have decreased 33% before increasing a total of 64% in 2008. The distribution pattern continued to fluctuate until 2012. The highest frequency for the reviewed articles is in 2008 where a total of 15% contributed to the overall distribution of the reviewed articles. Since year 2008 has the most number of published articles between 2000 until 2012, it is observed that only year 2008 has articles pertaining to all types of methodologies employed in engineering education published articles. Apart from published articles, unpublished articles were also sought to help minimise the risk of publication bias (The Joanna Briggs Institute for Evidence Based Nursing & Midwifery, 2001). Fortunately, this paper has also reviewed unpublished articles despite finding unpublished studies are difficult to source, since, by their very nature, there is generally no public record of unpublished articles. Hence, this paper summarizes of all past research on engineering education through both published and unpublished articles.

b) Frequent authors in JEE articles

*Table 1*: Frequently quoted authors in JEE from year 2000-2012

| No. | JEE Authors | Published Articles |
|---|---|---|
| **1.** | Felder, R. M | 10 |
| **2.** | Ohland, M. W | 7 |
| **3.** | Brent, R | 5 |
| **4.** | Besterfield, S. M | 5 |
| **5.** | Diefes-Dux, A. H | 4 |
| **6.** | Lackey, J. W | 4 |
| **7.** | Lackey, L. W | 4 |
| **8.** | Prince, M. J | 3 |
| **9.** | Brodersen, A. J | 2 |
| **10.** | Follman, D. K | 2 |
| **11.** | Hartman, H | 2 |
| **12.** | Hartman, M | 2 |

Table 1 shows the authors who have published frequently in JEE. A total of 12 authors have been identified in this paper. Felder was among the authors who have contributed the most number of articles in JEE pertaining to engineering education whereby 5% of the perceived articles in this paper have recognized Felder's research in engineering education studies. Three of Felder's articles pertained to motivation in engineering education. However, all the articles were published for undergraduates and the methodology employed was mainly qualitative. The situation for Brent is similar because Brent was the co-researcher for Felder in all the five published articles. On the other hand, Ohland has written the second highest number of articles in JEE where the articles emphasize on gender and motivation in engineering education. Ohland used a large database of sample among undergraduates to publish the outcome of both qualitative and quantitative based research paradigm. The articles were constructed on samples from 9 universities and a range of 75,000-100, 179 participants. Meanwhile, Besterfield, published a versatile pattern of articles where the perceived articles were published using undergraduates and middle school students, mainly in the Science, Technology, Engineering and Mathematics (STEM) field. The following authors also published a flexible research design although most of them employed higher institution participants in most of their articles.

c) Research areas involved in each article

There are 15 research areas that have been summarized from the 222 articles. Some articles have more than one research area but most of them have at least one main research area in their write up. A total of 239 research areas have been analysed. Figure 2 illustrates the type of research areas involved in each article of engineering education in the published articles. Each research area is also differentiated based on calculated percentages.

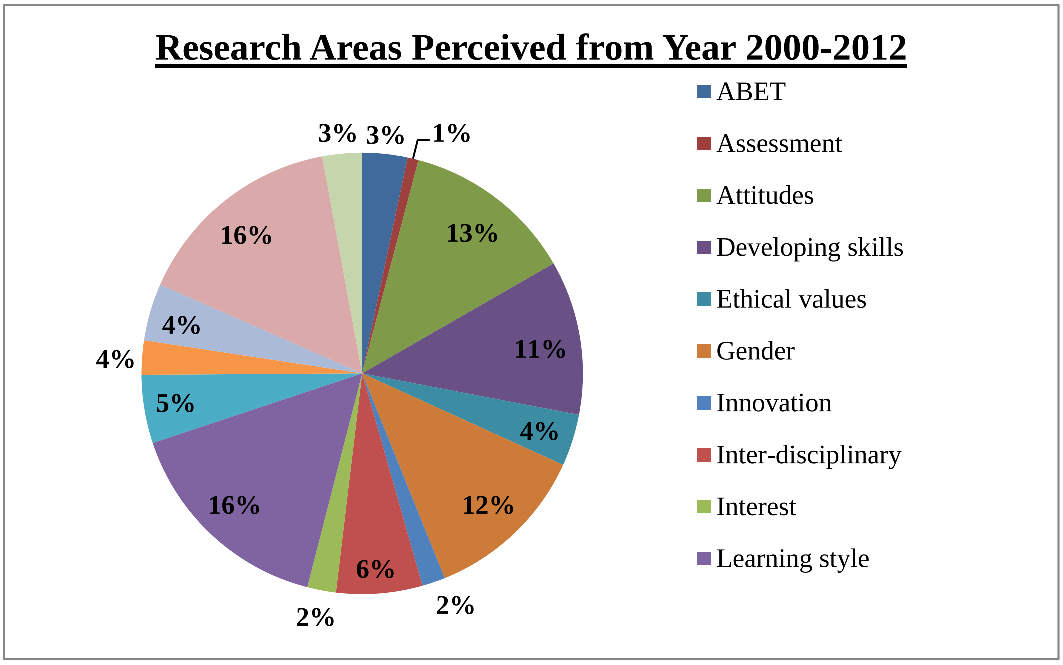


*Figure 2*: Research areas in engineering education from year 2000-2012

This paper perceives that both learning style and teaching method research areas are given more or less the equal priority by researchers within the 12 year period. A total percentage of 32% is highlighted on teaching and learning in engineering education. Apart from that, attitudes and gender research areas are also emphasised in the published articles. Gender research area has been stressed every year of the JEE publication, mainly researching on the involvement of women in engineering education. Parallel to that, areas such as developing skills and inter-disciplinary fields are also among the frequent research areas highlighted in engineering education. Subsequently, research areas such as motivation (5%), STEM education (4%), ethical values (4%), Accreditation Board for Engineering and Technology (ABET) (3%) and transformation of engineering education (3%) are also perceived in this paper. Transforming engineering education research area only started at the end of 2008 where issues such as mapping cultural landscape are stressed in a global scenario of engineering education.

The transformation also highlighted the practice, policy and industry in 6 different continents. Hence, some articles in JEE were published pertaining to the best practices and recommendations in order to revolutionise engineering education. As years passed by, issues such as sustaining and expanding using professional development and community action research were also observed in transformation of engineering education research area. These areas are also convoyed with research areas such as interest (2%), innovation (2%) and assessment (1%). Both interest and innovation were areas that were given lesser emphasis although in assessment, the system of assessment and formative pattern are revealed in the articles perceived. A total of 2.5% of articles researched on other areas such as students' misconception, academic trends, demographics, achievement, administration and research on reliability.

Among the stated 15 research areas, a sum of 5 research areas are analysed to scrutinise the highlighted issues in each research area. These perceived research areas are learning style, teaching method, attitudes, developing skills and inter-disciplinary. These areas were stressed since researchers have given high emphasis to them in the 12 years of publication. Apart from that, these perceived areas have also indicated the issues in a clear fashion to expose the importance of these issues in engineering education either globally or based on the respective countries of origin.

*Table2*: Research areas in engineering education

| No. | Research Areas & Issues | Number of Articles |
|---|---|---|
| **1.** | Learning style: | 38 |
| | cooperative | 8 |
| | teamwork | 5 |
| | collaborative | 4 |
| | conceptual | 4 |
| | inquiry-based | 2 |
| | design-based | 2 |
| | active learning | 2 |
| | goal-oriented | 1 |
| | distance learning | 1 |
| | student centred | 1 |
| | self-directed | 1 |
| | contextual | 1 |
| | online learning | 1 |
| | affective learning | 1 |
| | **Total issues perceived** | **34** |
| **2.** | Teaching method: | 37 |
| | problem solving | 6 |
| | web-based | 5 |
| | laboratory | 5 |
| | module | 4 |
| | hands-on | 2 |
| | pedagogical | 2 |
| | computational | 2 |
| | using theory | 1 |
| | inductive | 1 |
| | simulations | 1 |
| | **Total issues perceived** | **29** |
| **3.** | Attitudes: | 30 |
| | beliefs | 3 |
| | discipline | 3 |
| | self-efficacy | 3 |
| | decision making | 2 |
| | leadership | 2 |
| | risk taking | 1 |
| | anxiety | 1 |
| | responsible | 1 |

| | | |
|---|---|---|
| | self-managed | 1 |
| | research based (methodologies) | 1 |
| | **Total issues perceived** | **18** |
| **4.** | Developing skills: | 27 |
| | cognitive | 7 |
| | reasoning | 5 |
| | critical thinking | 3 |
| | analytical | 2 |
| | spatial abilities | 2 |
| | entrepreneurial | 2 |
| | designing | 1 |
| | intellectual | 1 |
| | non-technical | 1 |
| | **Total issues perceived** | **24** |
| **5.** | Inter-disciplinary: | 15 |
| | nanotechnology | 1 |
| | science-engineering | 1 |
| | economic-engineering | 1 |
| | biology & engineering | 1 |
| | research & scholarship | 1 |
| | pathway for innovations | 1 |
| | social science & engineering | 1 |
| | design, technology & engineering | 1 |
| | mathematics, science & engineering | 1 |
| | technology, engineering & computer science | 1 |
| | chemistry, mathematics, physics & computer science | 1 |
| | **Total issues perceived** | **11** |

The total issues perceived and the number of articles in each research area do not match since a handful of articles could not clearly mention the issues involved in the respective research. Thus, this paper discusses the articles which have evidently revealed the main issues of the research areas. However, despite gender research area contributing a total of 12% from the entire articles, it is observed that gender research area mainly discusses the difference between both men and women in engineering education apart from focusing solely on women rather than perceiving the progress and achievement of both genders. Professional development workshops, E-mentoring, electronic learning and cooperative learning are a few of the approaches that have been aimed at increasing women's participation in engineering.

Researchers of engineering education have highlighted the significance of studying in a group whether at school or university level. In either of the academic institutions, issues such as cooperative, teamwork and collaborative have been stressed in the advancement of learning style in engineering education. Learning in engineering education using cooperative style has dominated other issues of learning style since a total of 8 issues have been assembled in this paper. Subsequently, issues of teamwork and collaboration with each contributing five and four issues in total have been explored. These issues of studying in a group of people are often discussed in learning style research area as compared to issues such as goal-oriented, distance learning, student-centred, self-directed, contextual, online learning and affective learning. This is because all these issues have been explored once in every analysed article. However, studying the engineering field using concepts, inquiry, design and active learning has been highlighted more than once in engineering education research articles.

On the contrary, teaching method is also a crucial research area in engineering education since a total of 29 issues have been perceived in this paper. Teaching the engineering participants using problem solving technique was one of the major issues that have gained attention from the researchers. Apart from that, teaching engineering based on web, laboratory and module has been equally highlighted throughout the years in engineering education. Issues of teaching engineering using web-based which began in 2000, advanced to a higher stage when issues such as computational methods and simulations began to be stressed in research articles. Yet, conventional teaching issues such as pedagogical, theory and hands-on have not been neglected. In fact these issues were also highlighted in an undemanding manner in teaching engineering among the research participants in academic institutions.

Another vital research area is attitude because research on areas pertaining to attitude has been fluctuating within the 12 years under review. A total of 18 issues were perceived in this research area and issues such as beliefs, discipline, self-efficacy, decision making and leadership are analysed and assembled under the attitude research area. Most of these issues were grounded on engineering participants whether students or graduates where their intention to graduate in science and engineering has declined. In fact, they are failing to graduate in science and engineering because these participants according to perceived articles are switching to non-science major. Hence, the issues on decision making are also accentuated on choosing the right career for these research participants.

By the same token, developing skills has also attracted major concentration since various issues are identified pertaining to this research area. All the issues in developing skills are involved in the thinking process expected for non-technical and entrepreneurial issues. Starting from cognitive issue, followed by reasoning ability and critical thinking, all these issues are given priority in developing skills for engineering education. Likewise, skills such as entrepreneurial, spatial abilities and analytical thinking have also gathered attention from authors in their published articles. Intellectual skills are perceived to be an important element in studying engineering since all these issues are directly or indirectly related to higher order thinking skills.

The intersection between two different fields is also crucial in engineering education since the inter-disciplinary research areas have highlighted a total of eleven issues in this paper. Various intersections of field have been concentrated in the perceived articles. Apart from educational fields, there are also cross discipline among research, scholarship and pathways for innovations. However, there is a lack in combination of science and engineering as the emergence of these researches has yet to be covered especially in the newspapers and debates in common parlance.

d) Types of participant

There are six major groups of participants that were stressed in the published research articles. These groups of participants vary from middle school level up to university level. Research studies in engineering education have employed them as samples in order to gather feedback on the researched fields. The following Table 3 describes the type of participants involved and the number of samples gathered in each level of engineering participant.

*Table 3*: Type of participants in engineering education

| No. | Participant | Frequency |
|---|---|---|
| **1.** | Undergraduate | 136 |
| **2.** | Adults | 44 |
| **3.** | Students | 21 |
| **4.** | Faculty members | 15 |
| **5.** | Graduate | 12 |
| **6.** | Teachers | 4 |
| | **Total** | 232 |

It is observed that engineering education in JEE articles has highlighted the age group between 20-25 years old since a total of 59% of articles has focused on university undergraduates. Adults in this paper consist of participants between the age group of 19-60 years old and they comprise researchers, scientists, practitioners, engineers, supervisors, clients, subordinates, outsiders, technicians, engineering educators, engineering school directors, advisory board members, staff members and instructors. This is followed by students with the frequency of high school students being ten and middle school students numbering eight. Middle school students, who are aged between 11-15 years, were employed in the engineering education research, particularly the 8th graders aged 13-14 years depending on the country's education system. However, the sum of both the groups does not match the total frequency since three research articles only mentioned the terms of "students" and "schools". Thus the samples in the perceived articles could not be analysed in detail. Subsequently, faculty members who also apparently attached to university level are perceived to be employed as engineering participants in this review. Graduate participants also known as post-graduate students who are furthering their studies to masters, doctorate or post-doctorate level are also used in obtaining the respective findings for the engineering education field. Finally the teachers are only used a total of 4 times and all of them are involved in middle school and none at high school level.

With respect to both university and school, it is perceived that researchers prefer to employ matured participants as their research samples. This is because 89% of the employed participants are at higher level of education whereas only 11% of them are school based. Surprisingly only a handful of research has used teachers as participants in engineering education studies though these participants are also old and matured enough. This exposes that research on engineering education has underscored the most advanced level of education, leaving students and teachers in schools with much lesser attention. Research trend also discloses the extent of importance given to pre-elementary children since this group of participant have not been utilized in engineering studies over the years. Conceivably, researchers throughout the years have been directed by the policy makers rather than setting in critical and independent thoughts into their studies.

e) Methodological design employed

Methodological design trend for the past 12 years shows that six types of research design or method have been employed in engineering education. Although the total articles perceived in this review are 222, the total research design analysed is 204 because this paper could not discover the research design employed for 18 articles. However this paper has revealed the criteria of each research design that has been the reason as to indicate the type of research design employed. Table 4 illustrates the distribution of research design and the number of articles in engineering education.

*Table 4*: Research design in engineering education

| No. | Research design | Articles |
|---|---|---|
| 1. | Qualitative | 85 |
| 2. | Quantitative | 42 |
| 3. | Mixed method | 34 |
| 4. | Design & development research (DDR) | 17 |
| 5. | Review | 15 |
| 6. | Others | 11 |
| | **Total** | 204 |

The bulk of the perceived articles employed qualitative research design since a sum of 42% add on to the total number of articles. Qualitative research design has been popular over the years among all the engineering disciplines. In fact despite the sophisticated and advanced software for analysing research findings, engineering fields have still emphasized qualitative research as compared to other research designs. Engineering education studies are keen not only in researching the perceptions of experts but also concentrate on how a process takes place in engineering educational research.

Parallel to that, this review also observed that quantitative research design has been the second most common research design employed in this review with a percentage of 21%. Apart from that, mixed method design which employs both the qualitative and quantitative paradigm has been widely used in the engineering field. This is because mixed method design is only lower than qualitative design with a 4% of percentage from the overall research design in engineering education. In fact despite the researchers in engineering field not having employed many articles solely on quantitative design, the appearance of some quantitative design in the mixed method approach has revealed the overall usage of this design. Apparently, quantitative research design is still well utilized in the engineering field despite the dominance of qualitative research design throughout the 12 years of perceived articles in this review.

Design and development research (DDR) approach has been given lesser emphasis as compared to other research designs since 17 articles have conducted this practice in their respective research. Unfortunately, after 2001, only one to three articles have focused on DDR design which indicates the concentration on this crucial research design has faded. Contrary to this, 7% of the perceived articles have employed review. It is perceived that 13 articles which involved review in engineering education have concentrated on all the four types of participants who come from graduate, undergraduate, high school students and adults. Meanwhile only two articles have reviewed using meta-analysis review in engineering education research. The rest of the designs were based on unpublished articles from conferences, seminars, workshops, programmes and project-based research which are also equally crucial to be involved in this paper to minimise the risk of publication bias.

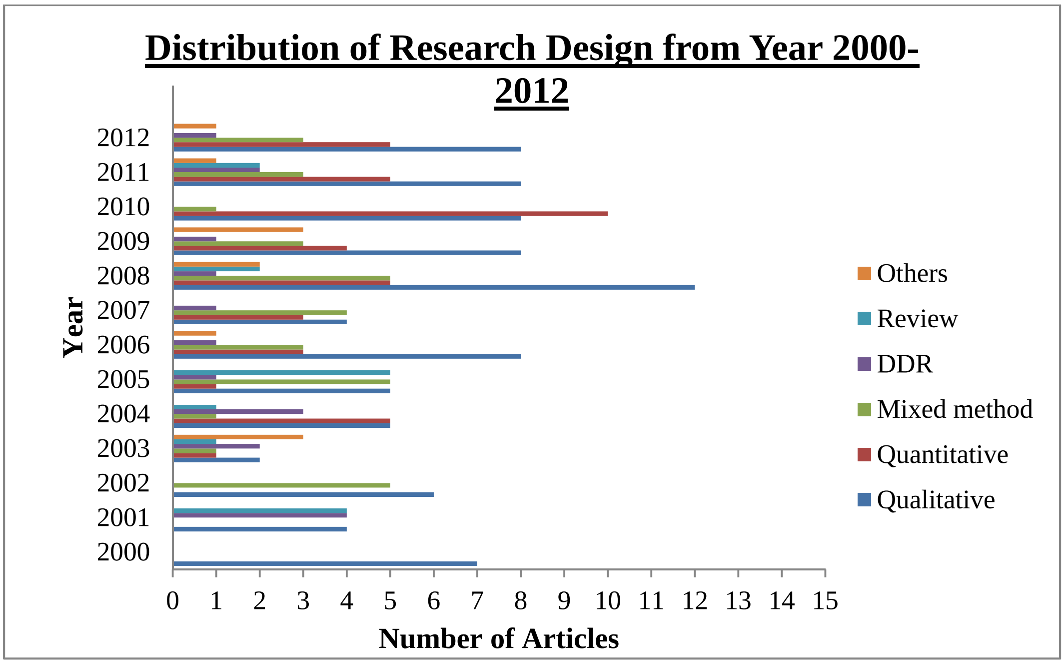


*Figure 3*: Distribution of research design

Figure 3 illustrates the trend of research design in engineering education over the past 12 years. Despite the popularity of qualitative research design among the researchers, as the years passed by, researchers began to employ quantitative, mixed method and DDR designs in their published articles. However the dominance of the qualitative paradigm has been detected over the period of 12 years because every year of publication had at least 2-4 minimum articles which employed qualitative design. Yet, it is also perceived that both quantitative and mixed method paradigms are also gaining attention although the number of articles using these designs is not as many as those using qualitative design. DDR design has been constantly published in engineering education research almost every year. Meanwhile, the numbers of articles which have employed both review and other research designs have fluctuated from time to time.

Since this paper has clearly perceived that qualitative approach has dominated in the methodology of studies, interview, observation, questionnaires and document analysis were among the qualitative research instruments that have been widely employed. Interviews have been held through online discussions, telephone conversations, face to face and focus groups. Meanwhile observations were carried out at site visits, classrooms and fields. Apart from that, questionnaires were associated with research terms such as comprehensive, exploratory and in-depth. Surveys were also widely held especially when the research involved a huge database of samples. Hence, survey via email was commonly carried out in these researches. Besides interpretation of novel ideas, analyses of both oral and written reports are also perceived in the engineering education articles.

Correspondingly, quantitative research design has also involved various research terms in this review. Since authors have employed experimental design, pre-posttest, control group, treatment group (experimental group), factorial design (2x2 and 3x2), post-hoc test and Structural Equation Modelling (SEM) has been the fundamental terms that have emerged during the review analysis. In fact, some JEE researchers have also utilized longitudinal, ethnographic, phenomenography and case study in their respective research fields. The trend of engineering education studies in JEE expose that researchers have made known their versatility and maturity in employing research approaches to produce their scholarly articles.

With respect to the methodological quality of research, this review has found that validity in most qualitative studies has been measured using a) triangulation, b) peer evaluations to reduce researcher bias, c) reference resources, comprising documents and audio tapes that allow analyses and d) confirmation of researchers' interpretations against the studied subjects. In contrast, validity in quantitative studies has been analysed using analysis of variance (ANOVA), multivariate analysis of variance (MANOVA) and *t*-test to produce inferential statistics. It is inevitable that reliability and validity are bound together in complex ways. Although there are studies using test re-test to measure reliability, most of the articles employed either quantitative or mixed method research design and used both coefficient alpha ($\alpha$-Cronbach) and Kuder-Richardson to measure the reliability for their respective engineering education research instruments.

**DISCUSSION**

Providing a foundation for the future of engineering learning is crucial because in recent years, there has been a concern about the need to develop a better understanding of how people learn engineering (Johri & Olds, 2011). This paper has identified that teaching and learning has been an important research issue throughout the 12 years of review.

Engineering education has emphasized the necessity of teaching and learning in groups. No one can be sure which teaching approach will be most successful with a particular group of students. Hence, cooperative, team-work and collaborative learning has been stressed by the researchers in the engineering field. Apart from that, problem solving and hands-on approach has also been highlighted in the engineering arena. Students do not learn by listening to lecturers but by actively engaging in the practice and processes associated with the lesson (Capobianco, 2011). While incorporating engineering approach into the lessons, Lee (2012) added that students not only worked cooperatively to develop problem solving and decision making skills but, at the same time, students can manage to think in a critical and creative manner to demonstrate a true understanding of concepts during the lessons. Parallel with that, hands-on activities increase the students' engagement and improve students' confidence in their ability to learn in engineering studies (Canfield, Ghafoor, & Abdelrahman, 2012).

Interdisciplinary fields have also gained much attention from the researchers pertaining to engineering education. It is inevitable that the advanced interception between science and engineering are perceived through robotic and nuclear energy where both scientific and engineering aspects are tightly interwoven. Johri and Olds (2011) suggested ways in which the learning of science and engineering education research communities might work to their mutual benefit. Johri and Olds (2011) concluded that there are many areas of mutual benefit for engineering education and the learning of science. It is certain that more inter-disciplinary research should be carried out, especially between science and engineering. However, this inter-disciplinary field should not be perceived only at higher level of education. This interception should also be concentrating at a younger stage of education to increase the interest and motivation among students in pursuing both science and engineering related careers.

In contrast, this paper has revealed that engineering field has been perceived only for matured thinking participants, mainly undergraduates and graduates. This perception is not true and more research has to be carried out to expose the importance of engineering besides revealing the mind of an engineer among elementary and secondary students as well. Apart from students, even the school teachers are not highlighted in engineering-based education. Teachers should be provided the opportunity in engineering field because teachers can gain new knowledge about teaching subjects such as science through the introduction of engineering apart from simultaneously becoming more effective science teachers (Capobianco, 2011). Moreover, teachers can work with reasonable guesses about student understanding in science-related concepts and the engineering design process (Capabianco, 2011).

In line with that, Science, Technology, Engineering and Mathematics (STEM) education is a topic of national discussion in countries which highlight education where many teachers have been expressing the need to include engineering concepts or designing activities at the elementary level (Bowman, 2012). During the past decade, there has been a surge of interest in design activities as a means to promote science learning (Beneson, 2001; Fortus et al. 2004; Harel, 1991; Kafai, 1994; Kolodner, 2002; Lehrer & Romberge, 1996; Lewis, 2006; NAE, 2008; Puntambekar & Kolodner, 2005; Roth et al., 2001). Apart from that, the intimidating world of engineering must be presented in a fun and meaningful way such that teachers returned to the classrooms and implemented the concepts with their science students (Evans, 2006). This is also one of the examples of interaction between science and engineering. Likewise, practitioners such as teachers and lecturers should enhance understanding of the nature of engineering education so that it does not become lost in any integration process.

This review also exposed that most of the researchers have employed qualitative research design as compared to other research designs. This scenario gives an outlook about the authors who often avoid getting locked into a rigid design that eliminates responsiveness but instead prefer to pursue new paths of discovery as the qualitative data emerge (Fraenkel, Wallen, & Hyun, 2012). While being open in adapting inquiry to deepen understanding, these researchers should also use the merged knowledge to DDR paradigms. DDR covers a wide spectrum of activities and interest apart from having implications on teaching and learning research (Richey & Klein, 2010). In fact understanding the theories involved in DDR provides extra knowledge in helping the researchers to improve the quality of teaching and learning for both students and teachers pertaining to engineering field (Reigeluth & Carr-Chellman, 2009).

This could also lead to new methods and ideas to avoid the shrinking engineering force that is evident in both developed and developing nations across the globe. Apart from the declining engineering force, the misconceptions and the loopholes that exist in certain engineering programmes could also be overcome by employing new solutions. However there is no disrespect for the contribution that the previous and present researchers have made in engineering over a period of 12 years, for all type of research issues and participants.

## CONCLUSION

Through a mixture of both past and recent articles to demonstrate the progress of engineering education, this paper has acknowledged the main concern and endorsements for the forthcoming research and development in Malaysian engineering education. With lesser emphasis provided on quantitative paradigm especially on effect sizes, this paper has still succeeded to outline the approaches taken by researchers from various countries to overcome the worrying state of engineering force among their science students. STEM education is the latest measure emphasised in order to instil interest for engineering field by nurturing science from a young age. Though this paper has only focused on JEE using ProQuest database, this study has also revealed the emergence of moving forward through a reflection of inter-disciplinary fields in engineering education. In fact the renaissance of engineering education offer Malaysian researchers mainly youngsters an opportunity to continue defining and embracing more fashionable mechanisms for the future Malaysian engineering education. We must keep in mind, however, that the objective of producing engineers should also highlight quality in terms of creativity and thinking skills apart from the number of engineers required to achieve Malaysia's Vision 2020 target.

**REFERENCES**

Aceituno, P., Campanario.M.L & Burgos,C. (2010). Sixth report innovacef: Good practices in the program Torres Quevedo, Innovacef.

Alemany, L., Alvarez,C.,Planellas,M.,&Urbano,D. (2010). Libro blanco de la iniciativa emprendedora en Espana. Fundacion Principle de Girona: Barcelona.

Ali, A. T. (2012). Teaching & Learning of Science & Mathematics in Schools: Towards a More "Creative & Innovative Malaysia". Paper presented at the Colloquium Science & Mathematics Education, University of Malaya, Kuala Lumpur.

American perspectives on engineers and engineering (2004). Retrieved fromhttp://www.aaes.org/harris_2004_files/frame.htm

Beneson, G. (2001). The unrealized potential of everyday technology as a context for learning. *Journal of Research in Science Teaching, 38*(7), 730–745.

Bers, U, M; M. P. (2005). Teaching partnerships: Early childhood and engineering students teaching math and science through robotics. *Journal of Science Education and Technology,14*(1),59-73.

Brumback, T., Schumacker, R., & Fonseca, D. (2010). A meta analysis of studies of cognition in engineering education. Paper presented at the American Society for Engineering Education Annual Meeting, Louisville, KY.

Canfield, S., Ghafoor, S., & Abdelrahman, M. (2012). Enchancing the Programming Experience for First-Year Engineering Students through Hands-On Integrated Computer Experiences. *Journal of STEM Education, 13*(4).

Capilla, R., Hervas, A., & Soriano, P. P. (2008). *Analisis de va evolucion de la demanda de studios universitarios de primer ciclo relacionados con la informatica y las telecomunicaciones.* Paper presented at the VIII Congreso de Technologias Aplicadas a la Ensenanza de la Electronica, Universidada de Valencia, Valencia.

Capobianco, B. M. (2011). Exploring a science teacher's uncertainty with integrating engineering design: An action research study. *Journal of Science Teacher Education, 22*, 645-660.

DeJarnette, N. K. (2012). America's children: Providing early exposure to STEM (Science, Technology, Engineering And Maths) initiatives. *Journal of Education, 133*(1), 77-84.

Ellis, P. D. (2011). The essential guide to effect sizes: Statistical power, meta-analysis and the interpretation of research results. United Kingdom: Cambridge University Press.

English, L. D., Hudson, Peter B., & Dawes, Les. A. (2011). *Middle school students' perceptions of engineering.* Paper presented at the STEM in Education Conference: Science, Technology, Engineering and Mathematics in Education Conference, Queensland University of Technology, Brisbane, Australia.

Engstrom, D. (2001). Ten components of a good technology education activity. *The Technology Teacher, 61*(3), 8-13.

Evans, J. (2006). Watkins Elementary is Gearing Up for Success by Integrating Children's Engineering in the Classroom. *The Children's Engineering Journal, 4*(1), 1-12.

Fortus, D., Dershimer, C., Krajcik, J., Marx, R., & Mamlok-Naaman, R. (2004). Design-based science and student learning. Journal of Research in Science Teaching, 41(10), 1081–1110.

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). *How to design and evaluate research in education* (8th ed.). New York, NY: McGraw-Hill.

Hamdan, H. (2012). Jumlah Pelajar Sains Di IPT Makin Kurang, Berita Harian. Retrieved from http://www.bharian.com.my/articles/JumlahpelajarsainsdiIPTmakinkurang/Article/

Harel, L. (1991). *Children designers*. New York, NY: Ablex.

Harris, P reveals public perceptions of engineering. (1998). Retrieved from http://www.nae.edu/NAE/naehome.nsf/weblinks/NAEW-4NHMEX?OpenDocument

Higher Education Ministry (1995). In Making Science Meaningful by Mageswary Karpudewan. (December 2012). *STAR*. Retrieved from http://www.thestar.com.my/story.aspx?file=%2F2012%2F12%2F9%2Feducation%2F1239824&sec=education

Humphrey, S. E. (2011). What does a great meta-analysis look like? *Organizational Psychology Review, 1*(2), 99-103.

INE. (2011). *Personal empleado en I+D por sector de ejecucion, ocupacion y sexos*, INE, Madrid.

Joanna Briggs Institute for Evidence Based Nursing & Midwifery. (2001). An introduction to systematic reviews. *Changing Practice, 1*, 1-6.

Johri, A., & Olds, M. B (2011). Situated Engineering Learning: Bridging Engineering Education Research and the Learning Sciences. *Journal of Engineering Education, 100*(1), 151-185.

Kafai, Y. B. (1994). *Minds in play: Computer game design as a context for children's learning*. Hillsdale, NJ: Erlbaum.

Katehi, L., Pearson, G., & Feder, M. A. (2009). *Engineering in K-12 education: Understanding the status and improving the prospects*. Washington, DC: National Academies Press.

Kieong, C. K. (2012). *Vision 100K.* The Institution of Engineers, 53rd Presidental Address, Malaysia.

Kolodner, J. (2002). Facilitating the learning of design practices: Lessons learned from an inquiry into science education. *Journal of Industrial Teacher Education, 39*(3), 9–40.

Lee, C. S. (2012). What a teacher needs the most. *The Children's Engineering Journal, 9,* 1-10.

Lehrer, R., & Romberge, T. (1996). Exploring children's data modeling. *Cognition and Instruction, 14,* 69–108.

Lewis, T. (2006). Design and inquiry: Bases for an accommodation between science and technology education in the curriculum? *Journal of Research in Science Teaching, 43*(3), 255–281.

Mena, I. B., & Diefes-Dux, H. A. (2012). First-year engineering students' portrayal of engineering in a proposed museum exhibit for middle school students. *Journal of Science Education and Technology, 21*(2), 304-316.

Ministerio de Ciencia e Innovacion. (2008). Paper presented at the Memoria de actividades de I+D+I (1996-2007), Ministerio de Ciencia e Innovacion.

Mioduser, D., & Levy, S. T. (2010). Making sense by building sense: Kindergarten children's construction and understanding of adaptive robot behaviours. *International Journal of Computer & Mathematics Learning, 15,* 99-127.

NAE & NRC (National Academy of Engineering & National Research Council). (2009). Engineering in K-12 Education: Understanding The Status & Improving The Prospects. Washington, DC: The National Academies Press.

NAS (National Academy of Science). (2007). Rising Above The Gathering Storm: Engineering & Employing America For A Brighter Economic Future. Washington, DC: The National Academies Press.

Nordin, K. (2012). Jumlah Pelajar Sains Di IPT Makin Kurang. Berita Harian. Retrieved from http://www.bharian.com.my/articles/JumlahpelajarsainsdiIPTmakinkurang/Article/

NRC. (1996). *National Science Education Standards*. Washington, DC: National Academies Press.

OECD. (2009). The global competition for talent. Paris, France: OECD Publications.

Pearson, G. (2004). Collaboration conundrum. *Journal of Technology Education, 15*(2), 66-76.

Petroski, H. (2003). Early education. *American Scientist, 91,* 206-209.

Poll, H. (2004). American Perspectives on Engineers and Engineering: Reveals Public Perceptions of Engineering :1998. From American Association of Engineering Societies. Retrieved from http://www.aaes.org/harris_2004_files/frame.htm

Puntambekar, S., & Kolodner, J. (2005). Toward implementing distributed scaffolding: Helping students learn science from design. *Journal of Research in Science Teaching, 42*(2), 185–217.

Reigeluth, C. M., & Carr-Chellman, A.A. (2009). *Instructional-design theories and models* (Vol. 3). New York, NY: Routledge.

Richey, R. C., & Klein, J. D. (2010). *Design and Development Research* (L. Akers, Ed.). Mahwah, NJ: Erlbaum.

Roth, W. M., Tobin, K., & Ritchie, S. (2001). Re/Constructing elementary science. New York, NY: Peter Lang.

Shallcross, L. (2006). Piecing it all together. *ASEE Prism, 16*(3). Retrieved from http://www.prismmagazine.org/nov06/tt_01.cfm

Tu, S. D. (2006). Total Engineering Education: The way to shape our future leadership. *Global Journal of Engineering Education, 10*(2).

Wendell, K. B; H.-S. L. (2010). Elementary students' learning of materials science practices through instruction based on engineering design tasks. *Journal of Science Educational Technology, 19,* 580-601.

Wicklein, R. C. (2006). Five good reasons for engineering as THE focus for technology education. *The Technology Teacher, 65*(7), 25-29.

United Nations Educational, Scientific and Cultural Organization (UNESCO) (2010). *Education for all: Global monitoring report.* Paris, France: Author.

**Appendix**

| | Identification | | | Methodological Characteristics | | |
|---|---|---|---|---|---|---|
| **No.** | Author(s) | Year | Issue(s) | Sample | Level | Type |
| **1.** | Randolph, G. B | April 2000 | Learning style (collaborative) | Not stated | Not stated | Not stated |
| **2.** | Croissant, J. L; Ogden, K; Ogden, G | April 2000 | Learning style (teamwork) | Not stated | Middle school students | Qualitative |
| **3.** | Friel, T | July 2000 | Learning style (conceptual) | Not stated | Undergraduate | Not stated |
| **4.** | Symams, M. D | July 2000 | Motivation | 180 | Middle school students | Qualitative |
| **5.** | Haller, C. R; Gallagher, V. J; Weldon, T. L; Felder, R. M | July 2000 | Learning style (cooperative) | Not stated | Undergraduate | Qualitative |
| **6.** | Horner, H. P; Royrvik, H. O | July 2000 | Gender | 17 colleges | Undergraduate | Qualitative |
| **7.** | Rutz, E | July 2000 | Learning style (distance learning) | 150 | Adults | Qualitative |
| **8.** | Fascetti, W.S; Leventman, P.G | July 2000 | Gender | 250 | Undergraduate | Qualitative |
| **9.** | Gallaher, J; Pearson, F | July 2000 | Gender | 100 | Undergraduate | Qualitative |
| **10.** | Boehm, R. F; Gallavan, N. P | Oct 2000 | Learning style (cooperative) | 16 | Undergraduate | Not stated |
| **11.** | Mehdi, M. R; Rizvi, S. A. I | April 2001 | Academic trend | 24 varsities | Graduate | Review (1982-1986) |
| **12.** | Candra, C; Kumar, S | April 2001 | Teaching method (web-based) | Not stated | Not stated | DDR |
| **13.** | Goulet, J | April 2001 | Learning style (goal-oriented) | 55 | Undergraduate | DDR |
| **14.** | Hyde, R. A; Karney, B. W | April 2001 | Learning style (affective learning) | Not stated | Middle school students | Review |
| **15.** | Haws, D. R | April 2001 | Ethical values | 42 papers | High school students & undergraduate | Meta-analysis (1996-1999) |
| **16.** | Sanad, H. A; Koushki, P. A | April 2001 | Gender | Not stated | Undergraduate & graduate | Qualitative |
| **17.** | Mirmiran, A | April 2001 | Interest & teaching method | Not stated | Undergraduate | Qualitative |
| **18.** | Garris, C. A | April 2001 | Teaching method | Not stated | Adults | Not stated |
| **19.** | Rashid, S | April 2001 | Inter-disciplinary (economics & engineering) | Not stated | Adults | Not stated |
| **20.** | Farr, J. V; Lee, A. M; Metro, R. A; Sutton, J. P | April 2001 | Developing skills (non-technical) | Not stated | Undergraduate | Review (case studies) |
| **21.** | Kulonda, D. J | July 2001 | Teaching method | Not stated | Undergraduate | DDR |
| **22.** | Pimmel, R | July 2001 | Learning style (cooperative) | Not stated | Undergraduate & faculty members | DDR |
| **23.** | Crown, S. W | July 2001 | Teaching method (web-based) | Not stated | Undergraduate | Qualitative |
| **24.** | Morell, L; Buxeda, R; Orengo, M; Sanchez, A | July 2001 | Learning style (cooperative) & STEM education | Not stated | Undergraduate & faculty members | Qualitative |
| **25.** | Landry, J. P; Pardue, J. H; Doran, M. V; Daigle, R. J | Jan 2002 | Attitude & motivation | Not stated | Undergraduate | Mixed method |
| **26.** | Nair, I; Jones, S; White, J | Jan 2002 | Teaching method | Not stated | Undergraduate | Qualitative |
| **27.** | Baker, S; Tancred, P; Whitesides, S | Jan 2002 | Gender | Not stated | Undergraduate | Qualitative |
| **28.** | Chesler, N. C; Chesler, M. A | Jan 2002 | Gender | Not stated | Adults & graduate | Qualitative |
| **29.** | Lackey, L. W; Lackey, J. W | Jan 2002 | Developing skills (cognitive) | Not stated | Undergraduate | Mixed method |
| **30.** | Wankat, P. C | Jan 2002 | Teaching method | 150 | Undergraduate & graduate | Qualitative |
| **31.** | Kuon, T. S; | Jan | Inter-disciplinary (science & | Not stated | Undergraduate | Mixed method |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Rice, M. P | 2002 | engineering) | | | |
| **32.** | Campbell, J. O; Bourne, J. R; Mosterman, P. J; Brodersen, A. J | Jan 2002 | Teaching method (simulations) | 120 | Undergraduate | Mixed method |
| **33.** | Felder, R. M; Felder, G. N; Dietz, E. J | Jan 2002 | Attitude | 116 | Undergraduate | Qualitative |
| **34.** | Rojas, E. M | Jan 2002 | Teaching method (web-based) | Not stated | Undergraduate | Qualitative |
| **35.** | Marks, B. P | Jan 2002 | Developing skills (cognitive) | Not stated | Undergraduate | Mixed method |
| **36.** | Raez, P. C; Groff, B. H | Jan 2003 | Inter-disciplinary (technology, engineering & computer science) | Not stated | Undergraduate | DDR |
| **37.** | Dym, C.L; Wesner, J. W;Winner, L | Jan 2003 | Ethical values | 57 | Adults | Forum |
| **38.** | Laeser, M; Moskal, B. M; Krecht, R; Lasich, D | Jan 2003 | Gender | Not stated | Adults | Project-based |
| **39.** | Lackey, L. W; Lackey, J. W; Grady, H. M; Davis, M. T | Jan 2003 | Teaching method | Not stated | Undergraduate | Quantitative |
| **40.** | Felder, R. M; Brent, R | Jan 2003 | ABET | Not stated | Adults | DDR |
| **41.** | Alexander, D. G; Smelser, R. E | Jan 2003 | Teaching method | Not stated | Adults | Qualitative |
| **42.** | May, G. S; Chubin, D. E | Jan 2003 | STEM education | Not stated | Undergraduate | Review (literatures) |
| **43.** | Delyser,R. R; Thompson, S. S; Edelstein, J; Lengsfeld, C; Rosa, A. J; Rullkoetter, P; Whitman, R; Whitt, M | July 2003 | Learning style (student centred) | Not stated | Faculty members | Project-based |
| **44.** | Chelser, N. C; Single, P. B; Mikic, B | July 2003 | Gender | Not stated | Faculty members | Qualitative |
| **45.** | Doolen, T. L; Porter, J. D; Hoag, J | July 2003 | Attitude | Not stated | Undergraduate | Mixed method |
| **46.** | Hersam, M. C; Luna, M; Light, G | Jan 2004 | Inter-disciplinary (nanotechnology) | Not stated | Undergraduate | Quantitative |
| **47.** | Ellis,T | Jan 2004 | Developing skills (cognitive) | Not stated | Adults | Quantitative |
| **48.** | McKenna, A. F; Agogino, A. M | April 2004 | Developing skills (reasoning) | Not stated | Middle & high school students | Quantitative |
| **49.** | Ressler, S. J; Ressler, E. K | April 2004 | Interest (internet based) | 30,000 | Middle & high school students | Qualitative |
| **50.** | Dearholt, D. W; Alt, K. J; Halpin, R. F; Oliver, R. L | April 2004 | Teaching method (web-based) | Not stated | Not stated | DDR |
| **51.** | Johnson, M. J; Sheppard, S. D | April 2004 | Gender | Not stated | Undergraduate & faculty members | Not stated |
| **52.** | Bjorklund, S. A; Parente, J. M; Sathianathan, D | April 2004 | Attitude | 1,500 | Undergraduate | Qualitative |
| **53.** | Sheng, J. H; Hsieh, P. Y | April 2004 | Teaching method (web-based) | 128 | Undergraduate | DDR |
| **54.** | Wiesner, T.F; Lan, W | July 2004 | ABET | Not stated | Undergraduate | Qualitative |
| **55.** | Pandy, M. G; Petrosino, A. J; Austin, B. A; Barr, R. E | July 2004 | Teaching method (module) | Not stated | Undergraduate | DDR |
| **56.** | Pappas, E. C; Kampe, S. L; Hendricks, R. W; Kander, R. G | July 2004 | Developing skills (critical thinking) | Not stated | Undergraduate & faculty members | Qualitative |
| **57.** | Felder, R. M; Brent, R | Oct 2004 | Developing skills (intellectual) | Not stated | Undergraduate | Review |
| **58.** | Giesey, J. J; Chen, Y: Hoshower, L. B | Oct 2004 | Motivation | Not stated | Undergraduate | Qualitative |
| **59.** | Zhang,G; Anderson, T. J; Ohland, M. W; Thorndyke, B. R | Oct 2004 | Demographic & academic characteristics | 87,167 | Undergraduate | Quantitative |
| **60.** | Diefes, D. A. H; Samant, C; Johnson, T. E; O'Connor, D | Oct 2004 | Teaching method (module) | Not stated | Undergraduate | Mixed method |
| **61.** | Blair, B. F; Millea, M; Hammer, J | Oct 2004 | Learning style (cooperative) | Not stated | Not stated | Quantitative |
| **62.** | Shuman, L. J; Besterfield, S. M; McGourty, J | Jan 2005 | ABET | Not stated | Not stated | Review |
| **63.** | Felder, R. M; Brent, R | Jan 2005 | Motivation & attitude | Not stated | Not stated | Review |
| **64.** | Smith, K. A; Sheppard, S. D; | Jan | Teaching method | Not stated | Undergraduate | Review |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Johnson, D. W; Johnson, R. T | 2005 | (pedagogical) | | | |
| **65.** | Dym, C. L; Agogino, A. M; Eris, O; Frey, D. D; Leiter, L. J | Jan 2005 | Developing skills (designing) | Not stated | Undergraduate | Review (12 years) |
| **66.** | Feisel, L. D; Rosa, A. J | Jan 2005 | Teaching method (laboratory) | Not stated | Undergraduate | Review |
| **67.** | Prados, J. W; Peterson, G. D; Lattuca, L. R | Jan 2005 | ABET | Not stated | Graduates | Not stated |
| **68.** | Litzinger, T. A; Wise, J. C; Sang, H. L | April 2005 | Learning style (self-directed) | 18 | Undergraduate | Mixed method |
| **69.** | Drake, M. J; Griffin, P. M; Kirkman, R; Swann, J. L | April 2005 | Ethical values & developing skills (reasoning) | Not stated | Undergraduate | Quantitative |
| **70.** | Sven, G. B; Kisenwether, E. C; Rzasa, S. E; Wise, J. C | April 2005 | Developing skills (entrepreneurial) | Not stated | High school students & undergraduate | Mixed method |
| **71.** | Rutar, T; Mason, G | April 2005 | Learning style (teamwork) | Each group (3-4) | Undergraduate | DDR |
| **72.** | Friesen, M; Taylor, K. L; Ron, M. G. B | July 2005 | Teaching method (module) | Not stated | Undergraduate & faculty members | Qualitative |
| **73.** | Thompson, N. S; Alford, E. M; Liao, C; Johnson, R; Matthews, M | July 2005 | Developing skills (cognitive) | Not stated | Undergraduate | Qualitative |
| **74.** | Whitman, L. E; Malzahn, D. E; Chaparro, B. S; Russell, M; et al. | July 2005 | Learning style (teamwork) | Not stated | Undergraduate | Qualitative |
| **75.** | Burtner, J | July 2005 | Attitude | Not stated | Undergraduate | Mixed method |
| **76.** | Shiavi, R; Brodersen, A. J | Oct 2005 | Teaching method (computational) | Not stated | Undergraduate | Mixed method |
| **77.** | McLoughlin, L. A | Oct 2005 | Gender | Not stated | Undergraduate | Qualitative |
| **78.** | Donath, L; Spray, R; Thompson, N. S; Alford, E. M; et al. | Oct 2005 | Learning style (inquiry-based) | Not stated | Undergraduate | Qualitative |
| **79.** | French, B. F; Immekus, J. C; Oakes, W. C | Oct 2005 | Gender | Not stated | Undergraduate | Mixed method |
| **80.** | Porter, A. L; Roessner, J. D; Oliver, S; Johnson, D | Jan 2006 | STEM education | Not stated | Undergraduate | Not stated |
| **81.** | Tonso, K. L | Jan 2006 | Learning style (teamwork) | Large scale | Adults | Mixed method |
| **82.** | Hutchison, M. A; Follman, D. K; Sumpter, M; Bodner, G. M | Jan 2006 | Gender, interest & achievement | 1387 | Undergraduate | Qualitative |
| **83.** | Hartman, H; Hartman, M | Jan 2006 | Gender | Not stated | Undergraduate | Qualitative |
| **84.** | Stren, F; Xing, T; Yarbrough D. B; Rothmayer, A; et al. | Jan 2006 | Teaching method (hands-on) | Not stated | Undergraduate & graduate | DDR |
| **85.** | Prince, M. J; Felder, R. M | April 2006 | Teaching method (inductive) | Not stated | Not stated | Qualitative |
| **86.** | Jonassen, D; Strobel, J; Lee, C. B | April 2006 | Teaching method (problem solving) | Not stated | Adults | Qualitative |
| **87.** | Dabbagh, N; Daniel, A. M | April 2006 | Teaching method (pedagogical) | 20 | Undergraduate | Qualitative |
| **88.** | Carpenter, D. D; Harding, T. S; Firelli, C. J; Montgomery, S. M; Passow, H. J | July 2006 | Attitude | 643 | Undergraduate | Mixed method |
| **89.** | Senay, Y; Baker, D; Robinson, K. S; Krause,S; Roberts, C | July 2006 | Inter-disciplinary (design, engineering & technology) | Not stated | Middle school teachers | Mixed method |
| **90.** | Reisslein, J; Reisslein, M; Seeling, P | July 2006 | Teaching method (problem solving) | Not stated | High school students | Quantitative |
| **91.** | Jarosz, J. P; Busch, V. I. J | July 2006 | ABET | Not stated | Undergraduate | Qualitative |
| **92.** | Fincher, S; Tenenberg, J | Oct 2006 | Teaching method (using theory) | Not stated | Adults | Quantitative |
| **93.** | Cantrell, P: Pekcan, G; Itaini, A; Velasquez, B. N | Oct 2006 | Teaching method (module) | Not stated | Undergraduate & middle school students | Project-based |
| **94.** | Roselli, R. J; | Oct | Assessment | Not stated | Undergraduate | Quantitative |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Brophy, S. P | 2006 | | | | |
| **95.** | Rover, D. T | Oct 2006 | Inter-disciplinary (mathematics, science & engineering) | Not stated | Middle school students | Qualitative |
| **96.** | Anonymous | Oct 2006 | Interest | Not stated | Adults | Not stated |
| **97.** | Anonymous | Oct 2006 | ABET | Not stated | Adults | Qualitative |
| **98.** | Nicholas, G. M; Wolfe, H; Besterfield, S. M; Shuman, L. J; Siripen, L | Jan 2007 | STEM education | 12,000 | Undergraduate | Mixed method |
| **99.** | Reisslein, J; Sullivan, H; Reisslein, M | Jan 2007 | Attitude | Not stated | Undergraduate | Quantitative |
| **100.** | Bauer, E. H; Moskal, B; Gosink, J; Lucena, J; David. M | April 2007 | Attitude | 112 | Undergraduate & faculty members | Quantitative |
| **101.** | Steif, P. S; Hansen, M. A | July 2007 | Administering (web-based) | Not stated | Adults | Quantitative |
| **102.** | Baker, D; Krause, S; Yasar, S; Roberts, C; Robinson, K. S | July 2007 | Gender | 9 | Graduate | Qualitative |
| **103.** | Murphy, T. J; Shehab, R. L; Reed, R. T; Foor, C. E; Harris, B. J; et al. | July 2007 | Gender | 185 | Undergraduate | Qualitative |
| **104.** | Moskal, B. M; Skokan, C; Kosbar, L; Dean, A; Westland, C; et al. | July 2007 | Teaching method (hands-on) | 11 districts | Middle school teachers | Mixed method |
| **105.** | Trevelyan, J | July 2007 | Developing skills (coordination) | Not stated | Adults | Qualitative |
| **106.** | Atman, C. J; Adams, R. S; Cardella, M. E; Truns, J; Mosborg, S; et al. | Oct 2007 | Attitude | 69 | Adults | DDR |
| **107.** | Kilgore, D; Atman, C. J; Yasuhara, K; Barker, T. J; Morozov, A | Oct 2007 | Gender | 160 | Undergraduate | Mixed method |
| **108.** | Taraban, R; DeFinis, A; Brown, A. G; Anderson, E. E; Sharma, M. P | Oct 2007 | Developing skills (cognitive) | 19 | Undergraduate | Qualitative |
| **109.** | Besterfield, S. M; Shuman, L. J; Wolfe, H; Clark, R. M; Yildrim, P | Oct 2007 | Learning style (teamwork) | Not stated | Undergraduate | Mixed method |
| **110.** | Gereffi, G; Wadhwa, V;Rissing, B; Ong, R | Jan 2008 | Developing skills (entrepreneurial) | Not stated | Graduates | Not stated |
| **111.** | Vogt, C. M | Jan 2008 | Developing skills (critical thinking) | 4 varsities | Undergraduate | Quantitative |
| **112.** | Qualters, D. M; Sheahan, T. C; Mason, E. J; Navick, D. S; Dixon, M | Jan 2008 | Inter-disciplinary (chemistry, mathematics, physics & computer Science) | 191 | Undergraduate | Quantitative |
| **113.** | Li, Q; McCoach, D. B; Swaminathan, H; Tang, J | Jan 2008 | Attitude | Not stated | Undergraduate | Mixed method |
| **114.** | Mendez, G; Buskirk, T. D; Lohr, S; Haag, S | Jan 2008 | Attitude | Not stated | High school students | Quantitative |
| **115.** | Mehalik, M. M; Doppelt, Y; Schuun, C. D | Jan 2008 | Learning style (design-based) | 1053 (30 classes) | Middle school students & teachers | Not stated |
| **116.** | Allen, K; Reed, R. T; Terry, R. A; Murphy, T. J; Stone, A. D | Jan 2008 | Reliability (coefficient Alpha) | Not stated | Adults | Mixed method |
| **117.** | Grimberg, S. J; Langden, T. A; Compeau, L. D; Powers, S. E | Jan 2008 | Attitude | Not stated | Undergraduate | Qualitative |
| **118.** | Borrego, M; Newswander, L. K | April 2008 | Inter-disciplinary | Not stated | Adults | Qualitative |
| **119.** | Leung, M. Y; Lu, X; Chen, D; Lu, M | April 2008 | Learning style & teaching method | Not stated | Undergraduate | Qualitative |
| **120** | Borrego, M; Streveler, R. A; Miller, R. L; Smith, K. A | April 2008 | Learning style (active learning) | Not stated | Adults | Workshops |
| **121.** | Koro, L. M; Douglas, E.P | April 2008 | Ethical values | Not stated | Not stated | Meta-analysis (2005-2006) |
| **122.** | Hutchison, G; Mica, A; Follman, D. K; Bodner, G. M | April 2008 | Attitude | 12 | Undergraduate | Qualitative |

| | | | | | | |
|---|---|---|---|---|---|---|
| **123.** | Walden, S. E; Foor, C | April 2008 | STEM education | Large database | Undergraduate | Qualitative |
| **124.** | Schuurman, M. K; Pangborn, R. N; McClintic, R. D | April 2008 | Gender | Not stated | Undergraduate | Qualitative |
| **125.** | Linsenmeier, R. A; Kanter, O. E; Smith, H. D; Linsenmeier, K. A;McKenna, A. F | April 2008 | Teaching method (laboratory) | Not stated | Undergraduate | Mixed method |
| **126.** | Rover, D. T | April 2008 | Learning style | Not stated | Adults | Review |
| **127.** | Streveler, R. A; Litzinger, T. A; Miller, R. L; Steif, P. S | July 2008 | Learning style (conceptual) | Not stated | Not stated | Not stated |
| **128** | Malcom, S. M | July 2008 | Gender | Not stated | Adults | Qualitative |
| **129.** | Adams, R. S; Felder, R. M | July 2008 | Motivation | Not stated | Adults | Not stated |
| **130.** | Fouger, X; Almgren, R; Gopalakrishnan, K; Mailkot, P | July 2008 | Inter-disciplinary | Not stated | Adults | Program |
| **131.** | Chubin, D; Donaldson, K; Olds, B; Fleming, L | July 2008 | Motivation | Not stated | Undergraduate | Qualitative |
| **132.** | Ohland, M. W; Sheppard, S. D; Lichtenstein, G; Eris, O; Chachra, D; et al. | July 2008 | Gender | Large database | Undergraduate & graduate | Qualitative |
| **133.** | Streveler, R. A; Litzinger, T. A; Miller, R. L; Steif, P. S | July 2008 | Learning style (conceptual) | Not stated | Not stated | Not stated |
| **134.** | Redish, E. F; Smith, K. A | July 2008 | Developing skills (cognitive) | Not stated | Undergraduate | DDR |
| **135.** | Atman, C. J; Kilgore, D; McKenna, A | July 2008 | Learning style (design-based) | Not stated | Undergraduate | Mixed method |
| **136.** | Colby,A; Sullivan, W. M | July 2008 | Ethical values | 7 varsities | Undergraduate | Qualitative |
| **137.** | Cox, M. F; Cordray, D. S | Oct 2008 | Inter-disciplinary (biology & engineering) | 28 | Undergraduate | Qualitative |
| **138.** | Lucena, J; Downey, G; Jesiek, B; Elber, S | Oct 2008 | Transformation of engineering education | Not stated | Adults | Not stated |
| **139.** | Trenor, J. M; Yu, S. L; Waight, C. L; Zerda, K. S; Sha, T. L | Oct 2008 | Gender | Diverse sample | Undergraduate | Mixed method |
| **140.** | Veenstra, C. P; Dey, E. L; Herrin, G. D | Oct 2008 | STEM education | Not stated | Undergraduate | Quantitative |
| **141.** | Martin, D. N; Saorin, J. L; Contero, M | Oct 2008 | Developing skills (spatial abilities) | Not stated | Undergraduate | Quantitative |
| **142.** | Natarajan, R | Oct 2008 | Attitude | Not stated | Not stated | Qualitative |
| **143.** | Wolfe, J; Powell, E | Jan 2009 | Gender | 6 | Undergraduate | Qualitative |
| **144.** | McKenna, A. F;Yalvac, B; Light, G. L | Jan 2009 | Learning style (collaborative) | Not stated | Faculty members | Not stated |
| **145.** | Marra, R. M; Rodgers, K. A; Shen, D; Bogue, B | Jan 2009 | Gender & attitude | 5 institutes | Undergraduate | Qualitative |
| **146.** | Jesiek, B. K; Newswander, L. K; Borrego, M | Jan 2009 | Attitude | Not stated | Adults | Qualitative |
| **147.** | Borrego, M; Douglas, E. P; Amelink, C. T | Jan 2009 | Inter-disciplinary (social science & engineering) | Not stated | Adults | Conference |
| **148.** | Vanasura, L; Stolk, J; Herter, R. J | Jan 2009 | Learning style | Not stated | Adults | DDR |
| **149.** | Moreno, R; Reisslein, M; Ozogul, G | Jan 2009 | Teaching method (problem solving) | Not stated | Undergraduate | Qualitative |
| **150.** | Brown, S; Flick, L; Fiez, T | Jan 2009 | Teaching method (laboratory) | Not stated | Undergraduate | Qualitative |
| **151.** | Ingram, S; Brunning, S; Mikawoz, I | April 2009 | Gender & attitude | Not stated | Undergraduate | Mixed method |
| **152.** | Charyton, C; Merrill, J. A | April 2009 | Innovation | 84 | Undergraduate | Quantitative |
| **153.** | Onyancha, R. M; Derov, M; Kinsey, B. L | April 2009 | Developing skills (spatial abilities) | Not stated | Undergraduate | Quantitative |
| **154.** | Genheimer, S. R; Shehab, R. | April | ABET | 90 | Adults | Qualitative |

| | | | | | | |
|---|---|---|---|---|---|---|
| | L | 2009 | | | | |
| **155.** | Nembhard, D; Yip, K; Shtub, A | April 2009 | Learning style (cooperative) | Not stated | Adults | Project-based |
| **156.** | Lin, C. C; Tsai, C. C | April 2009 | Teaching method (laboratory) | 321 | Undergraduate | Mixed method |
| **157.** | Lichtenstein, G; Loshbaugh, H. G; Claar, B; Chen, H. L; Jackson, K; et al. | July 2009 | Attitude | 2 institutes | Undergraduate | Mixed method |
| **158** | Jonassen, D. H; Shen, D; Marra, R. M; Cho, Y. H; Lo, J. L; et al. | July 2009 | Ethical values | Not stated | Undergraduate & graduate | Quantitative |
| **159.** | Leydens, J. A; Schneider, J | July 2009 | Innovation | 6 institutes | Undergraduate | Qualitative |
| **160.** | Zaftt, C. R; Adams, S. G; Matkin, G. S | July 2009 | Attitude | 81 | Undergraduate | Qualitative |
| **161.** | Abdulwahed, M; Nagy, Z. K | July 2009 | Teaching method (laboratory) | Not stated | Undergraduate | Quantitative |
| **162.** | Cantrell, P; Ewing, T. J | July 2009 | STEM education | 130 | High school students | Seminars |
| **163.** | Godfrey, E; Parker, L | Jan 2010 | Transformation of engineering education | 1 institute | Faculty members | Qualitative |
| **164.** | Mackey, K. R. M; Freyberg, D. L | Jan 2010 | Developing skills (cognitive) | Not stated | Graduate | Qualitative |
| **165.** | Rosenberg, K; Rinat, B;Plant, E.A; Doerr, C.E;Baylor, A. L | Jan 2010 | Gender & attitude | 119 | Undergraduate | Quantitative |
| **166.** | Hsuing, C. M | Jan 2010 | Learning style (cooperative) | 42 | Undergraduate | Quantitative |
| **167.** | Yadaz, A; Shaver, G. M; Meckl, P | Jan 2010 | Developing skills (critical thinking) | 73 | Undergraduate | Quantitative |
| **168.** | Carberry, A. R; Lee, H. S; Ohland, M. W | Jan 2010 | Attitude | 202 | Adults | Quantitative |
| **169.** | Jesiek, B. K; Borrego, M; Beddoes, K | April 2010 | Transformation of engineering education | 300 (6 continents) | Adults | Qualitative |
| **170.** | Felder, R. M; Brent, R | April 2010 | Motivation | Not stated | Faculty members | Qualitative |
| **171.** | Steif, P. S; Lobue, J. M; Kara, L. B; Fay, A. L | April 2010 | Teaching method (problem solving) | Not stated | Undergraduate | Mixed method |
| **172.** | Tran, N. A; Nathan, M. J | April 2010 | Developing skills (reasoning) | 140 | High school students | Quantitative |
| **173.** | Chen, J. C; Whittinghill, D. C; Kadlowec, J. A | April 2010 | Learning style (conceptual) | Not stated | Undergraduate | Quantitative |
| **174.** | Meyers, K. L; Silliman, S. E; Gedde, N. L; Ohland, M. W | April 2010 | Motivation | Not stated | Undergraduate | Quantitative |
| **175.** | Borrego, M; Froyd, J. E; Hall, T. S | July 2010 | Attitude & innovation | 197 | Adults | Quantitative |
| **176.** | Nichollas, G. M; Wolfe, H; Besterfield, S. M; Shuman, L. J | July 2010 | STEM education | Not stated | Middle school students | Quantitative |
| **177.** | Reisslein, M; Moreno, R; Ozogul, G | July 2010 | Learning style (contextual) | Not stated | High school students | Quantitative |
| **178.** | Koh, C; Tan, H. S; Tan, K. C; Fang, L; Fong, F. M, et al. | July 2010 | Motivation | Not stated | Undergraduate | Qualitative |
| **179.** | Heller, R. S; Beil, C; Dam, K; Haerum, B | July 2010 | Learning style (active learning) | Not stated | Undergraduate & faculty members | Qualitative |
| **180.** | Roger, S. W; Goktas, R. K | July 2010 | Motivation | Not stated | Graduate | Qualitative |
| **181.** | Matusovich, H. M; Streveler, R. A; Miller, R. L | Oct 2010 | Motivation | 11 | Undergraduate | Qualitative |
| **182.** | Baile, C; Ko, E; Newletter, W; Radcliffe, D. F | Jan 2011 | Inter-disciplinary (research & scholarship) | Not stated | Adults | Not stated |
| **183.** | Borrego, M; Bernhard, J | Jan 2011 | Learning style (inquiry-based) | Not stated | Adults | Quantitative |
| **184.** | Adams, R; Evangelou, D; English, L; De, F; Antonio, D; Mousoulides, N; et al | Jan 2011 | Inter-disciplinary (pathways for innovations) | Not stated | Adults | Qualitative |
| **185.** | Felder, R. M; Brent, R; Prince, M. J | Jan 2011 | Transformation of engineering education | Not stated | Adults | DDR |
| **186.** | Litzinger, T. A; Lattuca, L. R; Hadgraft, R. G; Newsletter, W. C | Jan 2011 | Motivation | Not stated | Adults | DDR |

| | | | | | | |
|---|---|---|---|---|---|---|
| **187.** | Johri, A; Olds, B. M | Jan 2011 | Learning style | Not stated | Adults | Qualitative |
| **188.** | Case, J. M; Light, G | Jan 2011 | Attitude | 7 | Not stated | Review |
| **189.** | Anonymous | April 2011 | Transformation of engineering education | Not stated | Not stated | Not stated |
| **190.** | Ohland, M. W; Brawner, C. E; Camacho, M. M; Layton, R. A | April 2011 | Gender | 75,000<br>9 varsities | Adults | Qualitative |
| **191.** | Beddoes, K; Borrego, M | April 2011 | Gender | 88 articles | Adults | Review (1995-2008) |
| **192.** | Capobianco, B. M; Diefes, D. H. A; Mena, I; Weller, J | April 2011 | Attitude & interest | 400 | Middle school students | Mixed method |
| **193.** | Dunsmore, K; Turns, J; Vellin, J. M | April 2011 | Learning style (collaborative) | Not stated | Undergraduate | Qualitative |
| **194.** | Min, Y; Zhang, G; Long, R. A; Anderson, T. J; Ohland, M. W | April 2011 | Gender | 100,179<br>9 varsities | Undergraduate | Qualitative |
| **195.** | McNair, L. D; Newswander, C; Boden, D; Borrego, M | April 2011 | Inter-disciplinary | Not stated | Undergraduate & faculty members | Qualitative |
| **196.** | Taraban, R | April 2011 | Developing skills (analytical) | Not stated | Undergraduate | Qualitative |
| **197.** | Stephens, R; Richey, M | July 2011 | STEM education | Large database | Middle & high school students | Qualitative |
| **198.** | Leppavirta, J | July 2011 | Attitude | Not stated | Undergraduate | Quantitative |
| **199.** | Lathern, S. A; Neumann, M. D; Hayden, N | July 2011 | Attitude | 125 | Undergraduate | Mixed method |
| **200.** | Stump, G. S; Hilpert, J. C; Husman, J; Chung, W. T; Kim, W. | July 2011 | Learning style (collaborative) & gender | 663 | Undergraduate | Quantitative |
| **201.** | Taraban, R;Craig, C; Anderson, E. E | July 2011 | Teaching method (problem solving) | Not stated | Middle school teachers | Mixed method |
| **202.** | Duncan, D; Diefes, D. H; Gentry, M | July 2011 | Transformation of engineering education | 40 | Undergraduate | Quantitative |
| **203.** | Hundhausen, C; Agarwal, P; Zollar, S. R; Carter, A | July 2011 | Teaching method (problem solving) | Not stated | Undergraduate | Quantitative |
| **204.** | Fantz, T. D; Siller, T. J; DeMiranda, M. A | July 2011 | Attitude | Not stated | Undergraduate | Program |
| **205.** | Genco, N; Holtta, O. K; Seepersad, C. C | Jan 2012 | Innovation | Not stated | Undergraduate | Quantitative |
| **206.** | Schaffer, S. P; Chen, X; Zhu, X; Oakes, W. C | Jan 2012 | Inter-disciplinary | 112<br>(34 teams) | Undergraduate | Mixed method |
| **207.** | Passow, H. J | Jan 2012 | ABET | Large database | Undergraduate | Quantitative |
| **208.** | Hsuing, C. M | Jan 2012 | Learning style (cooperative) | 42 | Undergraduate | Quantitative |
| **209.** | Engelbrecht, J; Bergsten, C; Kagesten, O | Jan 2012 | Developing skills (computational) | Not stated | Undergraduate | Qualitative |
| **210.** | Holsapple, M. A; Carpenters, D. D; Sutkus, J. A; Finelle, C. J; Harding, T. S | April 2012 | Ethical values | 18 campuses | Undergraduate & faculty members | Qualitative |
| **211.** | Daly, S. R; Adams, R. S; Bodner, G. M | April 2012 | Developing skills (analytical) | Not stated | Adults | Qualitative |
| **212.** | Mogana, A. J; Brophy, S. P; Bodner, G. M | April 2012 | Teaching method (computational) | 14 | Undergraduate & faculty members | Qualitative |
| **213.** | Lawton, D; Vye, N; Bransford, J; Sanders, E; Richey, M; et al. | April 2012 | Learning style (online learning) | Not stated | Undergraduate | DDR |
| **214.** | Brawner, C. E; Camacho, M. M; Lord, S. M; Long, R. A; Ohland, M. W | April 2012 | Gender | Large database | Undergraduate | Mixed method |
| **215.** | Litzler, E; Young, J | April 2012 | Attitude | Not stated | Undergraduate | Qualitative |
| **216.** | Harding, T. S; Carpenters, D. D; Finelle, C. J | April 2012 | Ethical value, developing skills (reasoning) & attitude | 380 | Undergraduate | Qualitative |
| **217.** | Diefes, D. H. A; Zawojewski, J. S; Hjalmarson, M. A; Cardella, M. E | April 2012 | Assessment | Not stated | Adults | Quantitative |

| | | | | | | |
|---|---|---|---|---|---|---|
| **218.** | Olds, B. M; Borrego, M; Besterfield, S. M; Cox, M | July 2012 | Transformation of engineering education | Not stated | Adults | Conference |
| **219.** | Prince, M. J; Vigeant, M; Nottis,K | July 2012 | Students' misconceptions | Not stated | Undergraduate | Quantitative |
| **220.** | Trytten, D .A; Lowe, A. W; Walden, S. E | July 2012 | Developing skills (intelligence) | Not stated | Undergraduate | Mixed method |
| **221.** | Finelli, C. J; Holsapple, M. A; Ra, E; Bielby, B. A; et al | July 2012 | Ethical value & developing skills (reasoning) | 4,000 (18 institutes) | Undergraduate | Qualitative |
| **222.** | Woodcock, A; Graziano, W. G; Branch, S. E; Ngambeki, I; Evangelou, D | July 2012 | STEM education | 544 | Undergraduate | Qualitative |