CHAPTER 5
SUMMARY AND CONCLUSIONS

5.1 STATEMENT OF THE PROBLEM

5.1.1 Need for Collaboration between Higher Engineering Educational Institutions and Industries

Engineering and technology play a major role in addressing the economic growth of any country. India’s vast network of academic infrastructure churns out over two million engineering graduates annually. The growth of engineering education in terms of quality is really remarkable but there are growing concerns about part of the existing available talent pool being unsuitable for employment due to a skill gap. It has become imperative to enhance the Indian talent pool to maximize the industry’s potential and enable the Industry to further catalyze the country’s galloping economic growth rate.

There is a need for effective intervention to understand requirements of the Industry, variable sector-specific skills, training requirements that improve business performance, articulation of business expectations in educational institutions and engagement of industry leaders with higher engineering educational institutions (HEEI). This necessitates developing more and more platforms that would bring together HEEI and industries to evolve modalities for collaboration in order to meet India’s medium and long-term skills and business needs for the future. Therefore, Institute–Industry Collaboration has been regarded as a natural progression of relationship from simple to higher level collaborations. This research attempted to
discuss the evolution of this relationship, the inherent bases of collaboration and the nature of various forms of collaboration.

5.1.2 Need for the Research Study

The Institute–Industry Collaboration has been increasingly valued by the academia and the degree of collaboration has been increasing over the years. But with the possible exception of a few studies, Institute–Industry Collaboration in HEEI in India remains an unexplored area and a detailed investigation is important to understand the collaboration pattern. In this context, the National Steering Committee on TEQIP constituted by National Project Implementation Unit (2013) expressed concern about the fact that the interface between academic institutions and industry had not taken off and there was an urgent need to tap its full potential under TEQIP.

National Knowledge Commission’s working group on engineering education (2008) reported that while the government increased investment in education and training as a proportion of national income, the effort was inadequate to address the direct needs of the corporate sector. This calls for a collaborative effort by both academia and industry. According to AICTE-CII survey report (2012) there is no encouraging picture on industry–institute interaction in engineering institutions in India.

In the workshop on Academia–Industry Collaboration, the Union Minister for Human Resource Development Shri. Pallam Raju (2013) observed that the current stage of industry–academia linkages in India today is happening in bits and pieces and it should require a sustainable and a long-term plan.
This motivated the researcher to study in detail the effectiveness of Institute–Industry Collaboration in HEEI. The findings of the study will be highly useful to higher engineering educational institutions for effective implementation of Institute–Industry Collaboration in replicating the developed model and adopting the suggested strategies.

5.1.3 **Statement of the Problem**

The problem of the research study is titled as “Effectiveness of Institute–Industry Collaboration in Higher Engineering Educational Institutions of Tamil Nadu”.

The research study was carried out to analyze the effectiveness of Institute–Industry Collaboration in HEEI located in the state of Tamil Nadu. The main purpose of the research study was to identify the parameters in Institute–Industry Collaboration, to determine how far they have been effective and the factors that play a major role in enhancing as well as limiting their effectiveness. The research study also aimed to develop an appropriate model and strategies for effective implementation of Institute–Industry Collaboration.

5.2 **OBJECTIVES OF THE RESEARCH STUDY**

1. To identify the important parameters that contribute to Institute–Industry Collaboration

2. To determine the effectiveness of Institute–Industry Collaboration in HEEI of Tamil Nadu
3. To identify the factors that play an important role in enhancing as well as limiting the effectiveness of Institute–Industry Collaboration

4. To develop an appropriate model and strategies for effective Institute–Industry Collaboration.

5.3 RESEARCH DESIGN

5.3.1 Approach to the Research Study

Keeping in view the objectives of the research study, the research has been designed to study the effectiveness of collaboration between HEEI and industries. The study is analytical and descriptive in nature. The design of the study involved the following methods.

(i) Conduct of survey

(ii) Collection of information from official documents, annual reports and websites of relevant institutions and agencies.

5.3.2 Parameters Studied

The twenty seven important contributing parameters for assessing the effectiveness of Institute–Industry Collaboration in HEEI were identified. These parameters according to their intrinsic characteristics under six broad categories of collaboration were studied and they are presented below:

Category 1 (C1) – General Collaboration represents personal informal collaboration which helps to buildup deeper levels of participation from industry.
Category 2 (C2) – Academic Level Collaboration involves a more specific collaboration of industry with higher level of participation than General Collaboration in HEEI.

Category 3 (C3) – Institutional Support Type Collaboration helps to overcome resource constraints of HEEI.

Category 4 (C4) – Service Type Collaboration helps the HEEI to generate financial resources by providing the services needed by industries.

Category 5 (C5) – Cooperative Type Collaboration involves formal research agreement under which original research is conducted in Institute–Industry Collaboration.

Category 6 (C6) – Student Level Collaboration helps the students to identify the industrial problems, to understand the best practices and needs of industries, and to generate funds for co-curricular activities.

5.3.3 Hypotheses of the Research Study

In the formulation of the hypotheses for the research study, the twenty seven parameters selected for assessing the effectiveness of HEEI in the area of Institute–Industry Collaboration formed the basis and the hypotheses have been grouped into four categories, namely
**Category 1:** Hypotheses relating to the difference between the faculty members with respect to the effectiveness of Institute–Industry Collaboration.

**Category 2:** Hypotheses relating to the difference between the mean ranks of parameters assessed by the faculty members with respect to the effectiveness of Institute–Industry Collaboration.

**Category 3:** Hypotheses relating to the difference between the students with respect to the effectiveness of Institute–Industry Collaboration.

**Category 4:** Hypothesis relating to the difference between the mean ranks of parameters assessed by the students with respect to the effectiveness of Institute–Industry Collaboration.

A total of 12 hypotheses have been formulated. They are presented below under the four categories.

**Category 1:**

**Hypothesis I** - There is no significant difference between the assessments of faculty members of different departments with respect to the effectiveness of Institute–Industry Collaboration.

**Hypothesis II** - There is no significant difference between the assessments of faculty members with different designation with respect to the effectiveness of Institute–Industry Collaboration.

**Hypothesis III** - There is no significant difference between the assessments of faculty members with different years of teaching experience with respect to the effectiveness of Institute–Industry Collaboration.
**Hypothesis IV** - There is no significant difference between the assessments of faculty members handling different programmes with respect to the effectiveness of Institute–Industry Collaboration.

**Category 2:**

**Hypothesis V** - There is no significant difference between the mean ranks of parameters in General Collaboration assessed by the faculty members with respect to the effectiveness of Institute–Industry Collaboration.

**Hypothesis VI** - There is no significant difference between the mean ranks of parameters in Academic Level Collaboration assessed by the faculty members with respect to the effectiveness of Institute–Industry Collaboration.

**Hypothesis VII** - There is no significant difference between the mean ranks of parameters in Institutional Support Type Collaboration assessed by the faculty members with respect to the effectiveness of Institute–Industry Collaboration.

**Hypothesis VIII** - There is no significant difference between the mean ranks of parameters in Service Type Collaboration assessed by the faculty members with respect to the effectiveness of Institute–Industry Collaboration.

**Hypothesis IX** - There is no significant difference between the mean ranks of parameters in Cooperative Type Collaboration assessed by the faculty members with respect to the effectiveness of Institute–Industry Collaboration.
Category 3:

**Hypothesis X** - There is no significant difference between the assessments of students of different departments with respect to the effectiveness of Institute–Industry Collaboration.

**Hypothesis XI** - There is no significant difference between the assessments of students in different years of study with respect to the effectiveness of Institute–Industry Collaboration.

Category 4:

**Hypothesis XII** - There is no significant difference between the mean ranks of parameters in Student Level Collaboration assessed by the students with respect to the effectiveness of Institute–Industry Collaboration.

5.3.4 **Instruments for Data Collection**

Instruments used are structured questionnaires and interview schedules.

A total of five instruments were developed by the research for collecting information from the following sources.

1. Academic administrators - Interview schedule
2. Placement coordinators - Questionnaire
3. Faculty members - Questionnaire
4. Students - Questionnaire
5. Representatives of industries - Interview schedule
5.3.5 Sample

In Tamil Nadu, there were 22 deemed universities offering engineering educational programmes during the study period and the list of deemed universities is given in Table 1.1. Nine deemed universities were selected using purposive sampling technique. The data required for the research study were collected from the following sources:

1. Academic administrators
2. Placement coordinators
3. Faculty members
4. Students
5. Representatives of industries

The methods used for selecting the samples are described below:

1. Academic administrators
   (i) Heads of institutions (Director and / or Principal)
   (ii) Heads of the departments

   Data were collected from 47 academic administrators (N = 47). This includes 14 heads of the institutions and 33 heads of the departments. The total number of academic administrators working in all 9 institutions is 59. The random sampling method was used. Data were collected from 80% of academic administrators.

2. Placement coordinators

   The placement coordinators work at two levels viz. at university level and at department level.
University placement and training cell is headed by Dean and duly supported by a Placement Officer and the department placement works are coordinated by a staff member. Data were collected from 47 placement coordinators (N = 47). This includes 9 from university placement and training cell and 38 from placement coordinating staff members of the departments. The total number of placement coordinators working in all 9 institutions is 63. The random sampling method was used. Data were collected from 75% of placement coordinators.

3. Faculty members

The number of faculty members in the institutions ranges from 85 to 240. The total number of faculty members working in all 9 institutions is 1,460. In each institution, the faculty members were subdivided into programme wise homogeneous groups viz. Civil Engineering, Mechanical Engineering, Electrical & Electronics Engineering, Electronics & Communication Engineering and Computer Science Engineering. Stratified random sampling method was used for selecting the faculty members. Data were collected from 20% of faculty members i.e. from 294 faculty members (N = 294).

4. Students

The number of students in the institutions ranges from 750 to 1,900. The total number of students studying in all the 9 institutions is 11,925. In each institution, the student population was stratified into sub-groups using the two variables i) programme of the study and ii) years of study (II year, III year and IV year) as the basis of stratification. Stratified random sampling method was used for
selecting the students. Data were collected from 7% of students i.e. from 850 students (N = 850).

5. **Representatives of industries**

By studying the Institute–Industry Collaboration documents published in the annual reports, information available in the official websites and information collected from the placement coordinators, it was arrived that the number of industries collaborating with the institution ranges from 10 to 50. The total number of industries collaborating with the 9 institutions is 270.

The representatives of industries for the study were selected by purposive sampling method and data were collected from 36 industries, with 2 persons from each of the industries, thus the total number is 72 (N = 72). Data were collected from 27% of representatives of industries.

5.3.6 **Methods of Data Collection**

The following methods were used for collecting the data for the research study:

1. Mailing the questionnaires in advance to the faculty members, students and placement coordinators of the engineering institutions under deemed universities

2. Two visits to each of the engineering institution under deemed universities for the following purposes:

   (i) Collecting the filled-in questionnaires

   (ii) Interviewing the academic administrators
3. Interviewing a small sample of placement coordinators, faculty members and students for cross validation of their responses collected through the questionnaire.

4. On-site visit to the collaborating industries for interviewing their representatives.

5.3.7 Data Analysis

The data which were collected with reference to the objectives of the study were analysed are presented below:

A. Assessment of the effectiveness of Institute–Industry Collaboration in HEEI of Tamil Nadu was done in two parts - viz.

- Determination of the effectiveness of Institute–Industry Collaboration as assessed by the faculty members

- Determination of the effectiveness of Institute–Industry Collaboration as assessed by the students.

The percentage of effectiveness of each type of collaboration was calculated.

B. The six hypotheses from Category 1 and Category 3 were tested by applying ANOVA followed by Duncan Multiple Range (DMR) test.

C. The six hypotheses from Category 2 and Category 4 were tested by applying Friedman test.
D. Identification of enhancing and limiting factors that play an important role on the effectiveness of Institute–Industry Collaboration was done by determining the overall perception of the three categories of respondents:

(i) Academic administrators
(ii) Placement coordinators
(iii) Representatives of industries, by using weighted mean score for each factor.

E. Model for effective Institute–Industry Collaboration:

A generic model for effective Institute–Industry Collaboration was developed by referring the various Institute–Industry Collaboration models presented in the literature and by studying the suggestions given by the stakeholders of HEEI to increase Institute–Industry Collaboration, and the model was validated by a panel of experts.

F. The strategies for effective Institute–Industry Collaboration were formulated on the basis of the multiple perspectives obtained by analyzing the data collected from various information sources.

5.4 MAJOR FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.4.1 Major Findings of the Research Study

1. Important Contributing Parameters for assessing the Effectiveness of Institute–Industry Collaboration

The twenty seven important contributing parameters for assessing the effectiveness of Institute–Industry Collaboration grouped under six categories of collaboration are presented in Table 5.1.
<table>
<thead>
<tr>
<th>Type of Institute–Industry Collaboration</th>
<th>Parameters Studied</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category 1 (C1) General Collaboration</strong></td>
<td>C1.1. Participation of industrial personnel in workshops</td>
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<td></td>
<td>C1.2. Participation of industrial personnel in conferences</td>
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<tr>
<td></td>
<td>C1.3. Participation of industrial personnel in seminars</td>
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<tr>
<td></td>
<td>C1.4. Participation of industrial personnel in guest lectures</td>
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<tr>
<td></td>
<td>C1.5. Participation of industrial personnel in committees</td>
</tr>
<tr>
<td><strong>Category 2 (C2) Academic Level Collaboration</strong></td>
<td>C2.1. Participation of industrial personnel in teaching process</td>
</tr>
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<td></td>
<td>C2.2. Conduction of continuing education for industries</td>
</tr>
<tr>
<td></td>
<td>C2.3. Involvement of industrial personnel in curriculum design</td>
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<tr>
<td></td>
<td>C2.4. Joint publication of papers with the industries</td>
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<tr>
<td></td>
<td>C2.5. Representation of industrial experts as external examiners for students</td>
</tr>
<tr>
<td><strong>Category 3 (C3) Institutional Support Type Collaboration</strong></td>
<td>C3.1. Participation of industries in research fellowships</td>
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<tr>
<td></td>
<td>C3.2. Contribution of funds to attend workshops by the industries</td>
</tr>
<tr>
<td></td>
<td>C3.3. Donation of instructional resource materials by the industries</td>
</tr>
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<td></td>
<td>C3.4. Donation of laboratory equipments by the industries</td>
</tr>
<tr>
<td></td>
<td>C3.5. Contribution for infrastructure development by the industries</td>
</tr>
<tr>
<td><strong>Category 4 (C4) Service Type Collaboration</strong></td>
<td>C4.1. Utilization of specialized laboratory equipments of the institute by the industries</td>
</tr>
<tr>
<td></td>
<td>C4.2. Conduction of training programmes for the industries</td>
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<tr>
<td></td>
<td>C4.3. Participation in consultancy assignment of the industries</td>
</tr>
<tr>
<td><strong>Category 5 (C5) Cooperative Type Collaboration</strong></td>
<td>C5.1. Participation in joint project with the industries</td>
</tr>
<tr>
<td></td>
<td>C5.2. Participation in joint research with the industries</td>
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<td></td>
<td>C5.3. Participation in joint patent with the industries</td>
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<tr>
<td><strong>Category 6 (C6) Student Level Collaboration</strong></td>
<td>C6.1. Participation in industrial visits</td>
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<td></td>
<td>C6.2. Participation in industrial project works</td>
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<td></td>
<td>C6.3. Participation in summer training</td>
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<td>C6.4. Participation in internships</td>
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<td>C6.5. Sponsor of medals and rewards</td>
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<td></td>
<td>C6.6. Contribution of funds for co-curricular activities</td>
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</tbody>
</table>
2. Effectiveness of Institute–Industry Collaboration in Higher Engineering Educational Institutions

In the present research study, the term effectiveness is the extent to which each type of collaboration has brought about the result intended, as assessed by the stakeholders. The term stakeholder refers to the persons of the organization who not only receiving the services but also who obtain a benefit.

(i) The percentage of effectiveness of the five categories of Institute–Industry Collaboration in HEEI assessed by the faculty members ranges from 51% to 65% (The percentage for each type of collaboration is given in Figure 4.1). Among the five categories of Institute–Industry Collaboration, Category 1 – General Collaboration (65%) was found to be the most effective type of Institute–Industry Collaboration and Category 5 – Cooperative Type Collaboration (51%) was found to be the least effective type of Institute–Industry Collaboration.

(ii) It was found that when effectiveness of anyone type of collaboration increases, the effectiveness of other types of collaboration also tend to increase and it was also found that the relationship between Category 3 (Institutional Support Type Collaboration) and Category 4 (Service Type Collaboration) is stronger and the relationship between Category 1 (General Collaboration) and Category 5 (Cooperative Type Collaboration) is weaker than the relationship between any other categories of Institute–Industry Collaboration.
(iii) The percentage of effectiveness of the sixth category of Institute–Industry Collaboration (Student Level Collaboration) in HEEI, as assessed by the students is 54% and in the Student Level Collaboration, the parameter C6.1 – participation in industrial visits was found to be the most effective type of Institute–Industry Collaboration and the parameter C6.5 – sponsor of medals and rewards was found to be the least effective type of Institute–Industry Collaboration.

2A) Difference among the Faculty Members in their Assessment of Effectiveness of various Categories of Institute–Industry Collaboration

(1) There is significant difference (at 5% level) in General Collaboration and Academic Level Collaboration in the assessments of faculty members of Civil Engineering, Mechanical Engineering, ECE, CSE and EEE departments.

a) In General Collaboration, Civil Engineering, ECE, CSE and EEE are significantly higher (at 5% level) on Institute–Industry Collaboration than Mechanical Engineering department but there is no significant difference between Civil Engineering, ECE, CSE and EEE departments.

b) In Academic Level Collaboration, EEE department is significantly higher (at 5% level) on Institute–Industry Collaboration than Mechanical Engineering and ECE
departments but Civil Engineering and CSE are not significant with other departments.

c) In overall effectiveness of Institute–Industry Collaboration, EEE is significantly higher (at 5% level) than Mechanical Engineering and ECE but Civil Engineering and CSE are not significant with other departments.

(2) There is significant difference (at 5% level) in Institutional Support Type Collaboration and Cooperative Type Collaboration in the assessments of faculty members of different designations.

a) In Institutional Support Type Collaboration, Associate Professor designation and Assistant Professor designation are significantly higher (at 5% level) on Institute–Industry Collaboration than Professor designation.

b) In Cooperative Type Collaboration, Associate Professor designation and Assistant Professor designation are significantly higher (at 5% level) on Institute–Industry Collaboration than Professor designation.

(3) There is no significant difference (at 5% level) in General Collaboration, Academic Level Collaboration, Institutional Support Type Collaboration, Service Type Collaboration and Cooperative Type Collaboration in the assessments of faculty members of different years of teaching experience.
There is significant difference (at 5% level) in General Collaboration in the assessments of faculty members handling different programmes.

a) In General Collaboration, faculty members handling PG programme are significantly higher (at 5% level) on Institute–Industry Collaboration than faculty members handling Ph.D. programme but faculty members handling UG programme are not significant with other groups.

2B) **Difference between Mean Ranks of Parameters assessed by the Faculty Members with respect to the Effectiveness of Institute–Industry Collaboration**

1) There is significant difference (at 1% level) between means ranks of parameters in General Collaboration.

   (a) In General Collaboration, participation of industrial personnel in guest lectures was found to be the most effective parameter (3.21) and participation of industrial personnel in committees (2.62) was found to be the least effective parameter.

2) There is significant difference (at 1% level) between means ranks of parameters in Academic Level Collaboration.

   (a) In Academic Level Collaboration, involvement of industrial personnel in curriculum design (3.48) was found to be the most effective parameter and joint publication of papers with the industries (2.52) was found to be the least effective parameter.
3) There is significant difference (at 1% level) between means ranks of parameters in Institutional Support Type Collaboration.

(a) In Institutional Support Type Collaboration, contribution of funds to attend workshops by the industries (3.22) was found to be the most effective parameter and contribution for infrastructure development by the industries (2.67) was found to be the least effective parameter.

4) There is significant difference (at 1% level) between means ranks of parameters in Service Type Collaboration.

a) In Service Type Collaboration, utilization of specialized laboratory equipments of the institute by the industries (2.17) was found to be the most effective parameter and participation in consultancy assignment of the industries (1.81) was found to be the least effective parameter.

5) There is significant difference (at 1% level) between means ranks of parameters in Cooperative Type Collaboration.

a) In Cooperative Type Collaboration, participation in joint project with the industries (2.18) was found to be the most effective parameter and participation in joint patent with the industries (1.75) was found to be the least effective parameter.
2C) **Difference between Students with respect to the Effectiveness of Institute–Industry Collaboration**

1) There is significant difference (at 1% level) in Student Level Collaboration in the assessments of students of Civil Engineering, Mechanical Engineering, ECE, CSE and EEE departments.

   a) In Student Level Collaboration, EEE is significantly higher (at 5% level) on Institute–Industry Collaboration than Mechanical Engineering and CSE but Civil Engineering and ECE are not significant with other departments.

2) There is significant difference (at 1% level) in Student Level Collaboration in the assessments of students in different years of study.

   a) In Student Level Collaboration, IV year students are significantly higher (at 5% level) on Institute–Industry Collaboration than II and III years of students but there is no significant difference between II year students and III year students.

3) There is significant difference (at 1% level) between means ranks of parameters in Student Level Collaboration.

   a) In Student Level Collaboration, participation in industrial visits (4.00) was found to be the most effective parameter and sponsor of medals and rewards (3.04) was found to be the least effective parameter.
3) **Enhancing and Limiting Factors on the Effectiveness of Institute–Industry Collaboration**

The ten factors that enhance and limit the effectiveness of Institute–Industry Collaboration are listed below:

**Enhancing factors**

a) Better understanding of existing capabilities for the development of industrial sector

b) Generating new science & technology (S&T) capabilities

c) Maintaining quality standards in academic and research & development (R&D) activities

d) Generation of R&D resources

e) Exposure to students to problem identification and research required in industry.

**Limiting factors**

a) Lack of mutual trust and appreciation

b) Lack of infrastructure facilities

c) Different work culture

d) Location of the industry

e) Non availability of dedicated manpower.
4) Identification of Enhancing and Limiting Factors that Play an Important Role on the Effectiveness of Institute–Industry Collaboration

Identification of important enhancing factors

Based on the perceptions of academic administrators, placement coordinators and representatives of industries, maintaining quality standards in academic and research & development (R&D) activities is rated as the most important enhancing factor followed by exposure to students to problem identification and research required in industry, better understanding of existing capabilities for the development of industrial sector, generating new science & technology (S&T) capabilities and generation of R&D resources.

Identification of important limiting factors

Based on the perceptions of academic administrators, placement coordinators and representatives of industries, lack of infrastructure facilities is rated as the most important limiting factor followed by lack of mutual trust and appreciation, non availability of dedicated manpower, different work culture and location of the industry.

5) Suggested Model for Effective Institute–Industry Collaboration

By referring the various Institute–Industry Collaboration models presented in the literature and by studying the suggestions given by the stakeholders of HEEI to improve Institute–Industry Collaboration, it was concluded that the institutions need a separate unit to coordinate and facilitate the various activities of Institute–Industry Collaboration. A generic model for Institute–Industry Collaboration applicable for HEEI was developed by the researcher and got
validated by a panel of experts. The components of the model and the various linkages between them are described in detail in Section 4.8.1.

6) Strategies for Effective Institute–Industry Collaboration

The strategies for HEEI for effective Institute–Industry Collaboration are listed below:

- Inclusion of Institute–Industry Collaboration as a thrust area in the strategic plan of the HEEI
- Effective implementation of Institute–Industry Collaboration in HEEI
- Involving the departments of HEEI in the Institute–Industry Collaboration
- Strengthening alumni association
- Assessment and analysis of needs of industries
- Nurturing industry focus culture
- Establishment of a system of reward and recognition for high performers
- Creation of a separate Institute–Industry Collaboration unit
- Identification and training of appropriate backup person for Dean.

As part of strategy, a methodology is suggested for effective implementation of Institute–Industry Collaboration activities in HEEI and the same is presented in Figure 4.4.
5.4.2 Conclusions

From the findings of the research study summarized in the previous section, the following conclusions have been arrived:

1) As Institute–Industry Collaboration involves a diverse set of activities, no single measure is able to capture the full range of such collaboration.

2) Twenty seven important parameters that contribute to Institute–Industry Collaboration in HEEI were identified.

3) The twenty seven parameters were grouped into six categories according to their intrinsic characteristics.

   Category 1 – General Collaboration

   Category 2 – Academic Level Collaboration

   Category 3 – Institutional Support Type Collaboration

   Category 4 – Service Type Collaboration

   Category 5 – Cooperative Type Collaboration

   Category 6 – Student Level Collaboration

4) With regard to the effectiveness of different categories of Institute–Industry Collaboration in HEEI as assessed by the faculty members, Category 1 – General Collaboration is the most effective (65%) and Category 5 – Cooperative Type Collaboration is the least effective (51%). It clearly indicates that there has been increased focus on improving personal informal collaboration but more efforts
should be made in improving formal collaboration such as consultancy and R&D activities in HEEI.

5) The effectiveness of Category 6 – Student Level Collaboration as assessed by students is 54% and in this collaboration the parameter (C6.1) - participation in industrial visits is the most effective type of Institute–Industry Collaboration and the parameter (C6.5) – sponsor of medals & rewards is the least effective type of Institute–Industry Collaboration. It shows that there has been increased focus in tuning the students to industry requirements by arranging industry visits and summer trainings but limited development has happened with regard to encouraging the best talent available in HEEI.

6) Across departments, there is significant difference in General Collaboration and Academic Level Collaboration. The assessments by the faculty members of different departments revealed the following:

(a) Civil Engineering, ECE, CSE and EEE departments have a higher level of General Collaboration than Mechanical Engineering department

(b) EEE department has higher level of Academic Level Collaboration than Mechanical Engineering and ECE departments. Civil Engineering and CSE departments have an insignificant level of collaboration in academic level activities.
7) Across designations, there is significant difference in Institutional Support Type Collaboration and Cooperative Type Collaboration. In the assessments of faculty members of different designations, Associate Professors and Assistant Professors have higher level of Institutional Support Type Collaboration and Cooperative Type Collaboration than Professors. It indicates that faculty members with Associate Professor designation and Assistant Professor designation are actively involved in consultancy and R&D related works.

8) Across years of teaching experience, there is no significant difference in General, Academic Level, Institutional Support Type, Service Type and Cooperative Type Collaborations.

9) Across the programmes handled, there is significant difference in General Collaboration. In the assessment of faculty members of different programmes handled,

(a) faculty members handling PG programme have a higher level of General Collaboration than faculty members handling Ph.D. programme

(b) faculty members handling UG programme have an insignificant level of General Collaboration.
10) With regard to the effectiveness of parameters in General Collaboration, participation of industrial personnel in guest lectures is most effective and participation of industrial personnel in committees is the least effective.

11) With regard to the effectiveness of parameters in Academic level Collaboration, involvement of industrial personnel in curriculum design is the most effective and joint publication of papers with the industries is the least effective.

12) With regard to the effectiveness of parameters in Institutional Support Type Collaboration, contribution of funds to attend workshops by the industries is most effective and contribution for infrastructure development by the industries is the least effective.

13) With regard to the effectiveness of parameters in Service Type Collaboration, utilization of specialized laboratory equipments of the institute by the industries is the most effective and participation in consultancy assignment of the industries is the least effective.

14) With regard to the effectiveness of parameters in Cooperative Type Collaboration, participation in joint project with the industries is the most effective and participation in joint patent with the industries is the least effective.
15) Across the departments, there is significant difference in Student Level Collaboration. In the assessments of students of different departments,

(a) EEE department has a higher level of Student Level Collaboration than Mechanical Engineering and CSE departments

(b) Civil Engineering and ECE departments have an insignificant level of Student Level Collaboration.

16) Across different years of study, there is significant difference in Student Level Collaboration. In the assessments of students of different years of study, IV year students have a higher of Student Level Collaboration than II and III year students. It indicates that more efforts should be taken from the II year onwards to interact with the industries.

17) The five identified factors that enhance the effectiveness of Institute–Industry Collaboration in the order of importance are:

(i) Maintaining quality standards in academic and R&D activities

(ii) Exposure to students to problem identification and research required in industry

(iii) Better understanding of existing capabilities for the development of industrial sector

(iv) Generating new S&T capabilities

(v) Generation of R&D resources.
18) The five identified factors that limit the effectiveness of Institute–Industry Collaboration in the order of importance are:

(i) Lack of infrastructure facilities
(ii) Lack of mutual trust and appreciations
(iii) Non availability of dedicated manpower
(iv) Different work culture
(v) Location of industry.

19) A generic model emphasizing the creation of Institute–Industry Collaboration unit acting as a single point of contact between institute and industry is developed.

The unit should adopt the role of a trustworthy facilitator with friendly disposition, flexible approach with focused goals.

20) The strategies for effective Institute–Industry Collaboration include inclusion of Institute–Industry Collaboration as the thrust area in the strategic plan, strengthening the alumni association and nurturing industry focus culture in HEEI.

5.4.3 Recommendations

The following recommendations are made based on the findings of the study. Institute–Industry Collaboration is a planned activity for the benefit of institute, industry, and government and recommendations are presented in three sections according to the level of intervention required, viz. (1) UGC (2) HEEI (3) industries.
5.4.3.1 Recommendations to University Grants Commission

- Develop policy to encourage different modes of Institute–Industry Collaboration at national level
- Encourage public-private partnership to create consortia and partnership research institutions
- Facilitate provision of tax exemption for the industries collaborating with HEEI
- Encourage and fund the setting up of technology park at institution’s campus
- Develop policy to support the institutions to accept donations from the industries for strengthening the infrastructure
- Setup more efficient funding mechanism for basic and applied research
- Allocate more funds for establishing Institute–Industry collaborating units
- Publish profile of top engineering institutions for Institute–Industry Collaboration at national level
- Recognize the institution and faculty members having strongest industry collaborations by way of citation, trophy, certificate and cash awards
- Include Institute–Industry Collaboration as one of the main criterion when appraising institutions.
5.4.3.2 Recommendations to Higher Engineering Educational Institutions

- Develop an institution-specific model for Institute–Industry Collaboration using the model developed in this study as a basis
- Encourage design of research plans, field study, students internships, curriculum development, visiting faculty and other academic activities in collaboration with the industry
- Establish industrial liaison unit to facilitate the coordination of industrial liaison activities
- Encourage sabbatical for faculty members at industries for a period of 3 to 4 weeks per academic year with full pay
- Encourage the faculty members to engage in consultancy work, joint research, joint patent and other R&D works along with the industries
- Establish an exclusive patent office to coordinate and help the faculty members in R&D
- Develop clear policies and guidelines for various type of Institute–Industry Collaboration at institutional level
- Prepare a consolidate database of facilities and expertise available in all the departments
- Strengthen the alumni association
- Develop an exclusive centralized reprographics centre for industrial related activities
• Encourage signing of MOUs with industries to ensure sustainability of the collaboration

• Ensure transparency in all operations

• Implement a system of reward and recognition for high performers.

5.4.3.3 Recommendations to Industries

• Adopt selected HEEI for implementation of Institute–Industry Collaboration activities

• Establish institutional liaison units to facilitate the coordination of institutional liaison activities

• Encourage their executives to serve in advisory boards and various committees of the institutions

• Encourage internships to the students

• Provide opportunities for industrial training for faculty members and students

• Encourage and promote joint research, joint publication, consultancy and joint filing of patents with the institutions

• Contribute fund towards joint testing centers, laboratory and centre of excellence

• Facilitate mutual sharing of resources
• Industrial associations to develop and to publish database of interested collaborating industries with their area of interest for such collaboration.

5.4.4 Suggestions for Future Research

The present study on the effectiveness of Institute–Industry Collaboration has paved way for several further studies:

1) The present study covered only deemed universities in HEEI. A similar study can be conducted covering other institutions such as central university, state university, private university, national institute and institute under State Legislature Act.

2) The present study considered only the state of Tamil Nadu. A similar study can be replicated in other states and regions.

3) The present study covered only five engineering departments namely, Civil Engineering, Mechanical Engineering, Electrical & Electronics Engineering, Electronics & Communication Engineering, Computer Science Engineering. A similar study can be conducted covering all other departments.

4) The present study did not cover the effect of various initiatives of government agencies in promoting R&D between institute–industry. A study can be conducted covering all the initiatives of government agencies.
5) A comparative study of the effectiveness of various models implemented by HEEI for Institute–Industry Collaboration may be undertaken

6) A comparative study of effectiveness of Institute–Industry Collaboration between two categories of institutions in India, viz. (1) University / University level institutions (2) Colleges / Institutions affiliated with university and the following three levels of industries (1) Small scale industries (2) Medium scale industries and (3) Large scale industries may be undertaken.

Epilogue

All the four objectives of the research study have been fully accomplished. As byproduct of the study, five instruments have been made available for the use of other researchers. The basic design of the study will serve as a prototype for assessing the effectiveness of Institute–Industry Collaboration in various types and levels of engineering educational institutions.