# The Identification of the Most Important Non-technical Skills Required by Entry Level Engineering Students When They Assume Employment

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**Abstract**

Successful cooperative education programs depend on a harmonious relationship of mutual benefit between employers, students and educational institutions. Institutions therefore need to continually examine what skills employers consider to be important with regard to the skills required by students first entering the workplace. The study was aimed at making a contribution toward cooperative education programs in engineering at technikons. Research revealed a skills gap between the skills students acquire in their formal study and what employers require. The skills that are not adequately addressed are non-technical skills. The study identified which of these skills employers considered to be the most important. It is recommended that the identified non-technical skills be incorporated into the formal engineering programs of students before they undergo experiential training in the workplace.

Technological, social and economic changes have made organizations more complex and heightened the need for providing skills other than technical skills to employees entering the workplace for the first time. Busse (1992) points out that as technology has become more instantaneously available, the skills of employees have become the employer's competitive edge. The workplace requires a new kind of worker with a broad set of skills which include, among others, problem solving, listening, negotiating and communication. Busse further states that employers refer to these competencies as non-technical skills.

Modern employers want entry-level employees to possess the correct combination of non-technical skills to complement job specific skills, such as engineering or accounting skills, for example (Busse, 1992; Lankard, 1990; Wiggill, 1991; and Young, 1986). While students currently receive adequate training in the technical skills for their future jobs, the non-technical skills are not receiving sufficient attention. In a summary of 14 studies that were conducted to establish the skills employers regard as important for entry-level employees, Natriello (1989) found that employers placed emphasis on correct work attitudes and non-technical skills. Wiggill (1991) states that deficiencies are evident amongst graduates entering the South African workplace. American, Australian and British studies also reveal that employers believe that entry-level employees are deficient in the broader non-technical skills and that educational institutions need to begin placing more emphasis on providing teaching and training in non-technical skills (Cotton, 1995).

Many employers believe that a skills gap exists between what is required in the workplace and what is being provided by institutions of tertiary education. Bradshaw (1985) writes that there is a mismatch between employer needs and educational response. He adds that in the changing workplace, employers require workers with positive personal qualities and work attitudes in addition to academic qualifications. Statsz, Ramsay, Eden, Melamid and Kaganoff (1996) referring to recent research, believe that the skills gap identified by employers, is more about work dispositions and attitudes than academic or technical skills. Guirdham (1990) concurs and adds that "whatever else we need in the way of systems, procedures and mechanisms, the process of social interaction, work attitudes and behaviours is the glue that holds organizations together" (p.3).

The changes in the workplace

and the perceived skills gap have direct implications for the training of engineering students. It is essential in any vocationally oriented educational training that the skills acquired by students should meet the requirements of employers as customers. It has become necessary for academic staff to continually compare what they believe to be important in the training of students with what employers believe is important, in order to eliminate any gap between what students learn within the tertiary education sector and what will be needed on-the-job (Wilson, 1987, pp. 97-103). Consultation between faculties and employers should occur on an on-going basis.

Both technikons and universities require their engineering students to spend a certain amount of time gaining practical experience in the workplace before they qualify. This practical, experiential training goes by different names such as pupil engineering training or cooperative education. At technikons it is called cooperative education. Sweeney (1994) believes that an essential element of a successful cooperative education program is the adequate preparation of students before they start their experiential (on-the-job) training. The most effective approach would be to incorporate the required non-technical skills into the engineering curriculum or by means of work preparation programs before placement, "so that students do not view work issues as entirely separate to their academic education" (Harris, 1983, pp.3-4). He adds that work-preparation programs should focus on the specific non-technical skills requirements of employers. Gardner and Koslowski (1991) suggest that work preparation programs should orient students before they enter their first job placement. The programs should be specifically aimed at assisting students to anticipate the norms, values and behavioral expectations of the work environment.

Morgan (1982) states that if students have correctly anticipated the expectations of the organizations they are joining, their transition to the workplace is a positive experience. Schein (1966) also found that the degree of anticipatory socialization affects the adjustment of newcomers to organizations. Anticipatory socialization refers to the degree to which an individual is prepared for work prior to entry and occupation of a position in an organization (Van Maanen, 1976). Morgan (1982) adds that the adjustment process of newcomers who have undergone anticipatory socialization will influence the extent of congruence that exists between the expectations of students and the organization. Confrontation between these two sets of expectations is one of the critical characteristics of organizational entry and newcomers experience this as reality shock (Schein, 1966). Morgan (1982) concludes that the process of anticipatory socialization has the effect of sharpening the positive features of the organization and dulling the negative features.

The need for skills that can be classified as non-technical is common to all organizations but the specific requirements with regard to particular non-technical skills will vary from organization to organization (Morgan, 1982). It may be argued that engineering students will gain maximum benefit from their experiential training if they are able to anticipate the non-technical skills that are required in the specific organizations they are to join. The study reported here was based on the premise that the anticipatory socialization of students for the engineering workplace, can be brought about by including the non-technical skills in work-preparation programs. This motivated the following question: What non-technical skills do entry-level engineering students need?

This represented the main problem of the research project which may be stated as:

> The identification of the most important non-technical skills required by entry-level engineering students when placed for experiential training.

In order to develop a research strategy for addressing the main problem, the following sub-problems were identified:

(1) What are the non-technical skills required by engineering students to prepare them for experiential training?

(2) In what order of importance do engineering employers rank the non-technical skills identified in the first sub-problem?

## Definition of Concepts

Several meanings are associated with the concept "non-technical skills" used in the study. According to Straub (1990), technical skills comprise the productive part of a job; for example, the typing skills of a secretary that are measurable, whereas non-technical skills represent the aspects common to all jobs, such as following instructions, communicating effectively and cooperating with others in teamwork. Neal (1983) states that there are two broad categories of non-technical employment qualities or skills. The first category consists of behaviors such as arriving for work on time, following instructions, displaying social skills and conduct acceptable to others, and effective communication. The second category consists of attitude-related characteristics such as adaptability, self-confidence, persistence, ambition and helpfulness. Bryce (1993) writes that non-technical skills include communication, interpersonal and problem-solving skills. Non-technical skills have also been described as the skills that are provided by liberal arts education (Breen, 1981).

For purposes of this study the term "non-technical" was used to describe the general skills such as communication, negotiation, teamwork, problem-solving, positive work attitudes and cooperation, which are not specific to any particular job position or workplace environment, but rather can be applied to a great number of tasks and jobs. Munce (1981) divides non-technical skills into two categories: functional and adaptive skills. The study focused on these two categories of non-technical skills, each of which is briefly described below.

Functional skills are the basic skills applied to tasks and are used to solve new problems and to go beyond one's training and past experience. Examples of functional skills are questioning, analyzing, communicating, organizing, listening, decision-making and forecasting (Murphy & Jenks, 1982).

Adaptive skills describe the manner in which employees conduct themselves and interact with the working environment, including relations with people, organizations, and physical conditions (Murphy & Jenks, 1982). These skills are closely related to personality traits and when used in the appropriate environment, help the worker to adapt to that environment. Adaptive skills are essential to becoming effective in any work or learning situation. Examples of adaptive skills are flexibility, tactfulness, positive work attitudes, creativity and assertiveness (Breen, 1981).

For the purpose of the study the following definition of non-technical skills applied: the skills that are required to complement job content skills to effectively perform tasks in a workplace environment, and include: functional skills which are the basic skills applied to tasks such as speaking, reading and writing, and form part of larger actions such as instructing and leading a team of workers; and adaptive skills which are required to "fit in" and contribute as a valuable member in the workplace.

## Developing a Non-technical Skills Cluster Model

The model was developed for the specific aim of providing the necessary content for constructing a questionnaire. The questionnaire, based on the model, was to be used for identifying which of the non-technical skills comprising the model, employers of entry-level engineering students considered to be the most important. The model was developed by means of two interdependent processes. A skills classification framework used for classifying non-technical skills identified in the literature survey had to be developed. The model was developed using an extractive process whereby the essential components of each non-technical skills cluster identified in the literature survey were itemized.

The skills classification framework and the skills clusters used in the study were derived from inspection and analysis of the various classification systems. The literature survey revealed that no commonly agreed upon classification framework existed. Although differences existed, a comparison of the various classification frameworks indicated that a common clustering of skill within skills categories and clusters was evident. Smith, Wolstencroft, and Southern (1989) write that on close analysis, in the research data on employer non-technical skill requirements, "specific skills seem to cluster under specific headings" (pp. 25-31).

Four functional skills clusters and four adaptive skills clusters were identified through inspection and analysis of classification systems found in the literature survey. Figure 1 represents the non-technical skills classification framework developed for the study and used for constructing the skills cluster model for entry-level engineering employees. The specific skills cluster headings (bottom section of Figure 1) were selected for the classification framework since they best provided a composite of the different terminology that is used for describing similar skills having different headings but having the same components.

The non-technical skills cluster model of entry-level engineering employees developed for the study is represented in Figures 2 and 3. Figure 2 contains the functional skills clusters, namely communication, creative thinking and problem-solving, and information management. The figure further reflects that the two functional skills clusters, creative thinking and problem solving were combined to form one cluster due to the similarity and complimentary nature of the skills components comprising these two clusters. Each skills cluster is defined in Figure 2 and Figure 3 and beside the respective skills clusters appear the components that fall within the respective clusters.

The definitions define the characteristics of the skills components that are grouped under the skills cluster headings and were formulated specifically

**Figure 1**
**Non-Technical Skills Classification Framework**

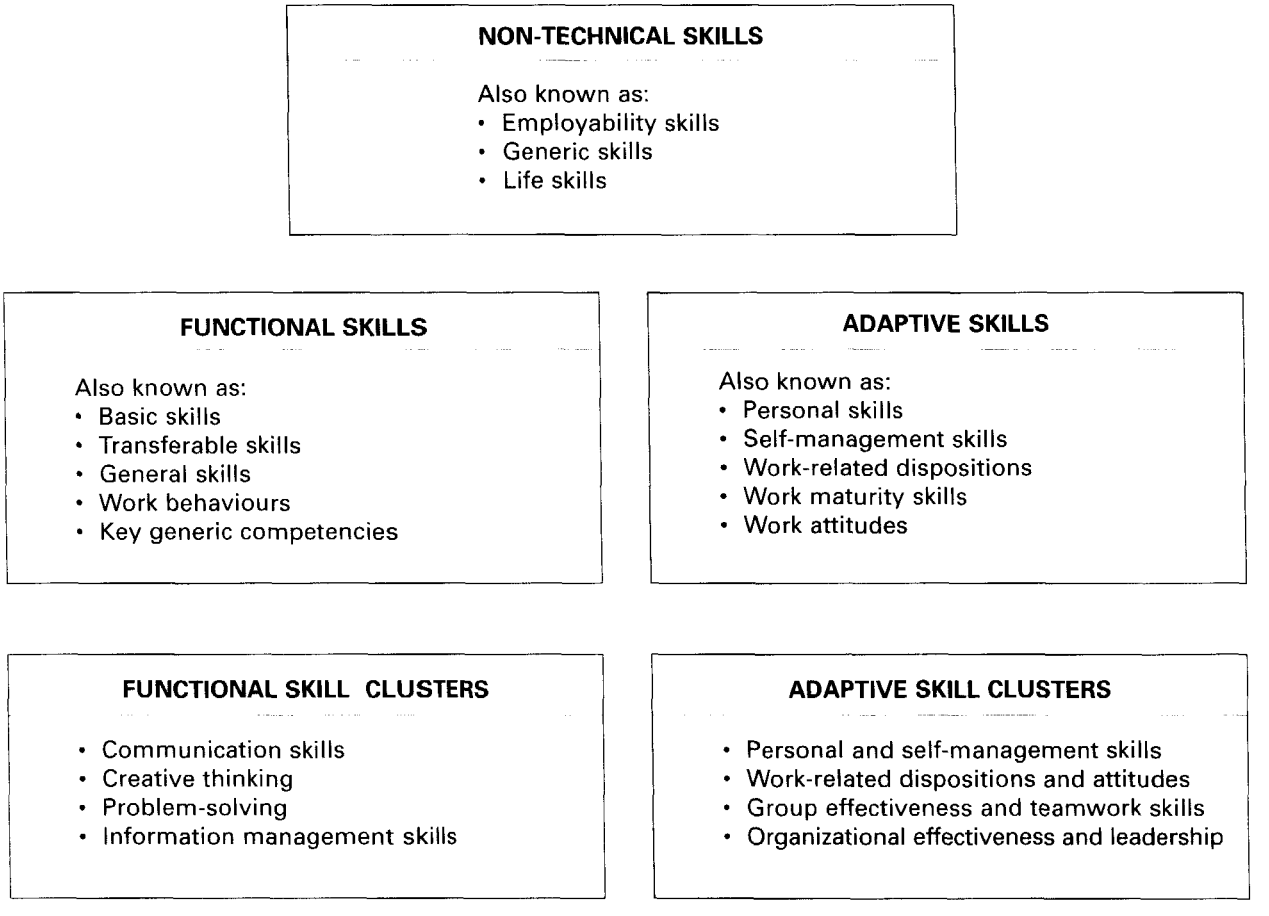

**Figure 2**
**Non-Technical Skills Cluster Model — Functional Skills Cluster**

| FUNCTIONAL SKILL CLUSTER | NON-TECHNICAL SKILLS COMPONENTS | |
|---|---|---|
| COMMUNICATION | The ability to exchange, transmit and express knowledge and ideas to achieve set objectives | |
| | • verbal communication<br>• teaching<br>• grievance handling<br>• listening<br>• conversational<br>• negotiation<br>• demonstration<br>• conflict management<br>• visual presentation<br>• technical report writing | • meeting procedure<br>• interviewing<br>• presentation<br>• selling<br>• reading<br>• persuasion<br>• instruction<br>• explanation<br>• graphic presentation |
| CREATIVE THINKING AND PROBLEM-SOLVING | The ability to solve existing and anticipated problems through creative innovative and analytical means | |
| | • questioning<br>• forecasting<br>• innovation<br>• formulation<br>• observation<br>• anticipate<br>• creative | • problem analysis<br>• integration<br>• investigation<br>• interpretation<br>• conceptualisation<br>• predictive<br>• facilitative |
| INFORMATION MANAGEMENT | The ability to arrange, sort and retrieve data, knowledge and ideas | |
| | • analyzing<br>• collection<br>• retrieval<br>• computer application<br>• research<br>• organization<br>• scheduling | • synthesizing<br>• sorting<br>• recording<br>• logical thinking<br>• valuation<br>• reporting<br>• prioritize |

for the study. An examination of the clusters reflect that they are comprised of non-technical skills components that have similar characteristics, are complimentary and interrelated. The model provided the necessary information for constructing the questionnaire aimed at determining which of the skills cluster components comprising the model, employers considered to be the most important.

## Methodology

*Questionnaire*

In order to solve the stated sub-problems in a logical manner, the following broad procedure was followed: A literature survey was conducted to identify the scope and range of non-technical skills that are required by entry-level employees in order to develop the non-technical skills cluster model described above. The model was then used for constructing the questionnaire for the empirical investigation. The empirical investigation was undertaken to determine which non-technical skills employers of engineering students considered to be the most important. Employers of engineering students were asked to indicate the non-technical skills components they regarded as important for students involved in the experiential training part of their studies (entry-level employees).

The employers were asked to rate each skills cluster component in terms of level of importance. A four-point rating scale was used, ranging from (1) extremely important, (2) important, (3) limited importance and (4) not important.

*Participants*

The entire population of employers that provide experiential training opportunities for engineering students at the Port Elizabeth Technikon were included in the empirical study. The population of employers was obtained from the Port Elizabeth Technikon's Integrated Tertiary System database of registered employers for the period June 1996 to June 1997. The database provided the names of employers directly involved with the mentoring of engineering students in the workplace.

The population consisted of 250 employers. The number of respondents per employer varied according to size of the organization. Multi-national employers with a number of branches falling within the geographical area of the study had larger numbers of respondents than smaller employers. All members within each organization who were listed on the database as being directly involved with the training of engineering students formed part of the research population. The size of the population to whom questionnaires were sent was 465. All members of the research population were identified by name, telephone number, and employer address. A total of 312 questionnaires were returned, representing a 67 percent response rate.

## Results

The responses to the questionnaire were statistically analyzed in order to determine in what order of importance engineering employers rank non-technical skills. Employer responses to each skills cluster component were analysed and interpreted separately to determine which non-technical skills components within each cluster were the most important to engineering employers (the ranking position of the components comprising the various skills clusters); and the level of importance (ranking) of the skills clusters to engineering employees.

The ranking position of the cluster components was determined by adding together the number of "extremely important" and "important" responses on each component. For example, in the study, the verbal communication component had 197 "extremely important" responses and 102 "important responses", resulting in a combined total of 299 responses. Expressed as a percentage of the total number of responses it is clear that this component was important. By means of this process, the 15 components comprising the communication skills cluster were ranked in order of importance from 1 to 15. The most important component was verbal communication and the least important was selling (15). These ratings are shown in Table 1.

A statistical method for ranking the components in each cluster was used to illustrate the relative importance of each skills component. It was decided to determine a cut-off point within the rankings to determine which skills components may

**Figure 3**
**Non-Technical Skills Cluster Model — Adaptive Skills Cluster**

| ADAPTIVE SKILL CLUSTER | SKILLS | | |
|---|---|---|---|
| SELF-MANAGEMENT AND PERSONAL STYLE | Indicators of general outlook, personal appearance, values, goals and motivation | | |
| | • self-confidence<br>• honest<br>• motivated<br>• assertive<br>• stable<br>• responsible<br>• ethical<br>• persistent | • disciplined<br>• determined<br>• flexible<br>• positive self-esteem<br>• integrity<br>• sincere<br>• adaptable<br>• patient | • dependable<br>• mature<br>• enthusiastic<br>• conscientious<br>• good appearance<br>• objective |
| WORK RELATED DISPOSITIONS AND ATTITUDES | Indicators of personal work orientation, work values, attitudes and understanding of the work environment | | |
| | • willing to learn<br>• team member<br>• understand teamwork<br>• task orientated<br>• take initiative<br>• punctual<br>• thoroughness<br>• precise<br>• handle pressure | • good work habits<br>• willing to be trained<br>• committed to the job<br>• respect for property<br>• make extra effort<br>• accept criticism<br>• give credit<br>• open-minded<br>• pride in work | • respectful<br>• self-control<br>• handle stress<br>• take risks<br>• understanding of the work environment<br>• interest in work |

| ADAPTIVE SKILL CLUSTER | SKILLS | | |
|---|---|---|---|
| GROUP EFFECTIVENESS AND TEAMWORK | The ability to use the correct combination of interpersonal skills to direct and guide a team to complete tasks and attain goals | | |
| | • put people at ease<br>• sensitive to cultural diversity<br>• negotiate<br>• solicitation<br>• social commitment<br>• helpful<br>• responsive<br>• hospitable | • lead and manage<br>• even tempered<br>• co-ordination<br>• outgoing<br>• supervize<br>• co-operate<br>• praise<br>• tactful<br>• counselling | • empathy<br>• persuasive<br>• compatible<br>• recruit ideas<br>• group process skills<br>• summarize |

| | |
|---|---|
| ORGANIZATIONAL EFFECTIVENESS AND LEADERSHIP | The ability to effectively contribute towards the successful completion of set organizational goals |

- goal directed
- handle stress
- meet deadlines
- have vision
- work to schedule
- delegate
- lead
- prioritize
- direct
- administration
- follow procedures
- co-ordinate
- put theory into practice
- work under pressure
- set objectives
- assume responsibility
- make suggestions
- manage
- supervise
- instruct
- time management
- motivate
- apply policies
- recommend

be regarded as relatively more important than others. The cut-off point was arbitrary to some extent, even though it was calculated using the following statistical method.

The cut-off score for each skills cluster was determined by the sum of all the "extremely important" and "important" responses expressed as a percentage of all the responses. The cut-off score for the communication skills cluster (61.47%) presented in Table 1 (bottom of the third column from the left), was obtained from the sum of the "extremely important" and "important" responses (1080 + 1796 = 2876) expressed as a percentage of the sum of all the responses (1080 + 1796 + 1300 + 503 = 4679). Therefore 2876 / 4779 x 100 = 61.47%. In Table 1 components with rank orders 1 to 7 are above the cut-off point. These skills components falling above the cut-off point are relatively more important than those falling below. It is suggested that those components falling above the cut-off point should be considered for inclusion in engineering curricula or work preparation programs for engineering students.

Figure 4 is self-explanatory and does not require much elaboration. The skills are arranged in order of support they received with number one being regarded by employers as the most important and the others in declining order. If one takes the top three skills within each of the functional skills clusters, it shows that under communication there are verbal communication, listening skills, and the ability to explain things. Under creative thinking and problem-solving the top three are problem analysis, the ability to observe astutely and questioning skills. Under information management there is logical thinking, analysis and the ability to prioritize.

The adaptive skills that received sufficiently strong statistical support are shown in Figure 5. It can be seen in Figure 5 that a significantly larger number of skills within the respective adaptive skills clusters received strong support. Figure 5 needs little elaboration other than to note those skills within each skills cluster that received strongest support.

The skills clusters were ranked in order of importance as perceived by employers and illustrated in Table 2. Table 2 indicates that the two skills clusters that received the strongest support (communication and creative thinking and problem-solving) fell into the functional skills clusters. Next were the adaptive skills and lastly in the rank order was information management. This rank order can be used to guide providers of engineering training at institutions of tertiary education to where emphasis may be placed in non-technical skills training.

## Recommendations

Four recommendations can be made from this study. Firstly, the findings should be considered

**Figure 4**
**A summary of the most important functional skills required by Port Elizabeth Technikon engineering students to prepare them for the job**

| FUNCTIONAL SKILLS |
|---|
| **COMMUNICATION** |
| 1. Verbal communication |
| 2. Listening |
| 3. Explanation |
| 4. Technical report writing |
| 5. Reading |
| 6. Visual and graphic presentation |
| 7. Demonstration |
| **CREATIVE THINKING AND PROBLEM-SOLVING** |
| 1. Problem analysis |
| 2. Observing |
| 3. Questioning |
| 4. Interpreting |
| 5. Investigating |
| 6. Innovating |
| 7. Anticipating |
| 8. Formulating |
| **INFORMATION MANAGEMENT** |
| 1. Logical thinking |
| 2. Analysis |
| 3. Prioritizing |
| 4. Reporting |
| 5. Computer application |
| 6. Recording |
| 7. Collection |

by the academic staff of engineering faculties when making course and curriculum design decisions so that training in the non-technical skills forms part of the curriculum. Secondly, staff involved with cooperative education programs should ensure that students are adequately prepared before placement for their experiential training. Thirdly, student counselors and staff involved with student development should, through extra-curricular programs, encourage the development of the identified skills. Fourthly, engineering students should be encouraged to participate in student societies since it could play a role in developing some of the required non-technical skills.

## Conclusion

This study has indicated that non-technical skills should be incorporated into the training of engineering students, and it has shed light on which skills are regarded by employers as the most important. Although the study was conducted in a limited geographical area, the results provide useful insight. The study could fruitfully be replicated in other geographical areas to provide comparative data. In the meantime, it is strongly recommended that the findings be heeded by providers of engineering training at institutions of tertiary education.

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**Figure 5**
**A summary of the most important adaptive skills required by Port Elizabeth Technikon engineering students to prepare them for the job**

**ADAPTIVE SKILLS**

SELF-MANAGEMENT AND PERSONAL STYLE
1. Motivated
2. Responsible
3. Self-confidence
4. Honesty
5. Integrity
6. Disciplined
7. Enthusiastic
8. Positive self esteem
9. Adaptable
10. Determined
11. Flexible
12. Conscientious
13. Ethical
14. Dependable
15. Stable

WORK RELATED DISPOSITIONS AND ATTITUDES
1. Thoroughness
2. Willing to learn and be trained
3. Committed to job
4. Interest and pride in work
5. Respect for property
6. Understand teamwork
7. Precise
8. Make extra effort
9. Task orientated
10. Punctual
11. Good work habits
12. Take initiative
13. Understand work environment
14. Handle pressure and stress

GROUP EFFECTIVENESS AND TEAMWORK
1. Co-operate
2. Responsive
3. Helpful
4. Co-ordination
5. Compatible
6. Group process skills
7. Tactful
8. Even tempered
9. Sensitivity to cultural diversity
10. Lead and manage
11. Recruit ideas
12. Summarize

ORGANIZATIONAL EFFECTIVENESS AND TEAMWORK
1. Meet deadlines
2. Work to schedule
3. Goal directed
4. Assume responsibility
5. Put theory into practice
6. Work under pressure
7. Prioritize
8. Make suggestions
9. Set objectives
10. Time management
11. Handle stress
12. Follow procedures
13. Motivate
14. Co-ordinate

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**Table 1**
**Employer rating of communication skills components**

| Rank Order | Skill Component | Component Number | Extremely Important | Important | Limited Importance | Not Important | Total | Composite Rating % |
|---|---|---|---|---|---|---|---|---|
| 1 | Verbal communication | 1 | 197 | 102 | 6 | 7 | 312 | 95.8 |
| 2 | Listening | 4 | 163 | 126 | 19 | 4 | 312 | 92.6 |
| 3 | Explanation | 15 | 118 | 155 | 34 | 5 | 312 | 87.5 |
| 4 | Technical report writing | 9 | 133 | 125 | 37 | 17 | 312 | 82.7 |
| 5 | Reading | 13 | 90 | 146 | 66 | 10 | 312 | 75.6 |
| 6 | Visual/grahic presentation | 8 | 72 | 137 | 81 | 22 | 312 | 67.0 |
| 7 | Demonstration | 6 | 42 | 155 | 99 | 16 | 312 | 63.1 |
| 8 | Meeting procedure | 10 | 47 | 138 | 99 | 27 | 312 | 59.5 |
| 9 | Persuasion | 14 | 40 | 142 | 106 | 24 | 312 | 58.3 |
| 10 | Teaching and instruction | 2 | 37 | 128 | 122 | 25 | 312 | 52.9 |
| 11 | Negotiation | 5 | 38 | 128 | 118 | 28 | 312 | 53.2 |
| 12 | Conflict management | 7 | 32 | 105 | 124 | 51 | 312 | 43.9 |
| 13 | Grievance handling | 3 | 31 | 90 | 130 | 61 | 312 | 39.8 |
| 14 | Interviewing | 11 | 14 | 66 | 142 | 90 | 312 | 25.6 |
| 15 | Selling | 12 | 26 | 53 | 117 | 116 | 312 | 25.3 |
| | | SUM | 1080 | 1796 | 1300 | 503 | | |
| | | % | 23.08 | 38.38 | 27.78 | 10.75 | | |
| | | CUT-OFF SCORE | 61.47 | RANGE | 70.51 | | | |

**Table 2**
**Ranking of skills cluster according to employer rating of skills clusters**

| Ranking | Skills Cluster | Extremely Important | Important | Composite Importance Rating % |
|---|---|---|---|---|
| 1 | Communication | 60 | 38 | 98 |
| 2 | Creative thinking and problem-solving | 53 | 43 | 96 |
| 3 | Group effectiveness and teamwork | 52 | 40 | 92 |
| 4 | Work related dispositions and attitudes | 33 | 58 | 91 |
| 5 | Self-management and personal style | 19 | 65 | 87 |
| 6 | Organizational effectiveness and leadership | 33 | 52 | 85 |
| 7 | Information management | 19 | 65 | 84 |

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