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# The Exploratory and Confirmatory Factor Analysis for Supervisory Input Support as the Determinant of Effective Supervision in Technology and Engineering Education

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**Abstract:** This study investigates the predictors of Supervisory Input Support (SIS) for effective supervision. This element is analyzed for the practical implementation of effective supervisory practice for students in technology and engineering education. There are reports regarding supervision issue during their final year project supervision which requires a great and informative input from their supervisors. A sample of 360 students completed survey including measures of Management Input, Interpersonal Input, Academic Input, Project Input and Technical and Innovation Input. The sample was selected through stratified random sampling. All factor loading were set to be >0.6. An exploratory analysis was conducted and Structural Equation Modeling (SEM) was employed to investigate the Confirmatory Factor Analysis (CFA) for SIS. The Goodness of Fit (GOT) was in good condition and the final model is proposed. This study introduces the elements that mounting the function of SIS. This study clarifies that the supports needed by students are different from one to another. If the supervisor could cater these challenges by providing effective inputs, the supervision process may enhance the supervision activity.

**Key words:** Student's supervision, supervisor, effective supervision, supervisory support, interpersonal input

## INTRODUCTION

The roles of a supervisor may become dominant when it comes to supervision. When a supervisor decides to supervise a project means undertaking to work in close collaboration with someone who is embarking on a journey within themselves: a journey which may at times profoundly exciting but which will also certainly be difficult, risky and painful (Salmon, 1992). A research degree is about research training as well as contributing to the knowledge and although it is not impossible to find ways of training oneself, the whole process is designed to be guided by a supervisor (Cryer, 2000). Therefore, both student and supervisor must wish the relationship to succeed. Otherwise, the problems in the relationship can affect the student's progress.

**Problem statement:** Higher education is now focusing on the quality of the students and the outcomes of their research. While striving for on time graduation, a student sometimes encounters many problems in their research. It becomes worse when they are also having personal problems such as finance, family, health and personality. At this stage, supervisor's role is utmost vital in maintaining their motivation to complete their studies. There are reports that students feel disappointed with their supervisor's role (Russell, 1996). Thus, effective inputs from their supervisor may assist the postgraduate process.

**Objective:** This study will discuss the important elements in supervisory input through Structural Equation Modeling (SEM) and Exploratory Factor Analysis (EFA). The inputs that should be practiced will be proposed according to the results. There are three important questions that were addressed in this study which are:

- What are the dimensions for Supervisory Input Support (SIS)?
- What are the determinant factors for SIS using Confirmatory Factor Analysis (CFA)?
- What is the underlying structure of SIS using Exploratory Factor Analysis (EFA)?

**Supervisory Input Support (SIS):** Investigating the best element for supervisory support needs to be carried out in a systematic way. This study grouped the elements into a few important inputs. According to Frick (2007), he

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proposed five inputs namely managerial input, research input, academic input, language input and interpersonal input. These inputs can be said cover all the process during the research or supervision. An amendmend was made to enhance the SIS with implementation of innovation and creativity element. The final dimension in SIS are managerial input, project/research input, academic/language input, interpersonal input and technical/innovation input.

On the othe hand, Terry and Frank identified 80 variables that were deemed to be significant to explain the supervisory and support needs for both supervisor and students. The method employed utilized a quasi-Delphi technique in which they worked on the documents simultaneously and yet iteratively, made reasoned judgments through the comparison of differences that arose. The 80 variables were further clustered into eight groups. Each of the groups was factored according to whether they were classified as 'structural', 'support' or 'exogenous'. The 'structural' factor is defined as those elements supplied principally by the supervisor(s) in negotiation with the candidate. They are generally directive aspects and incorporate the variable groups of the organizational process, the accountability stages and skills provision. The elements of this factor assist in the management process of the framework.

One of the elements for Supervisory Input Support is Interpersonal Input. Various studies have reported on the importance of interpersonal relationships between students and their supervisors as a determinant of student success (Lessing and Schulze, 2002; Ives and Rowley, 2005; Lin and Cranton, 2005). Malfroy (2005) reports that students often experience frustration as a result of a perceived lack of support or what is referred to as "a disjunction in expectations" between the student and the supervisor. Cryer (2000) showed that only highly committed students will successfully complete their research degrees if the relationship with their supervisors is poor. This shows that the importance of motivation to be part of the predictor for SIS. Therefore, a supervisor and student must have a very good relationship and be very close to each other (Ismail *et al.*, 2011).

Project and research input is considered as the pillar to the successful of the supervision. Lessing and Schulze (2002) describe the supervisory role as a balancing act between various factors: expertise in the area of research, support for the student, critique and creativity. Ives and Rowley (2005) emphasize the importance of matching supervisors to graduate students in terms of both topic expertise and working relationships. These reearchers also note the changing needs of graduate students which may necessitate a change in supervisory practices as student's progress through a graduate program. Malfroy (2005) adds that an open approach to supervision and a collaborative approach to learning may achieve more in terms of developing a community of scholars than more traditional approaches to supervision. Lessing and Schulze (2002) furthermore recommend that supervisors receive training in order to meet their student's needs effectively. Lessing and Schulze (2002) determined that a varied pattern of supervisory involvement in the research process produces the best results. This pattern involves a significant initial investment in time and effort in formulating the research question followed by less interaction and more monitoring during the implementation phase and finally increased input during the eventual writing of the research report. These findings indicate that a differentiated approach to providing information and support to students may be necessary. Lessing and Lessing (2004) adds that there needs to be a balance between supervisor input and student independence. Thus, it is suggested that a supervisor should guide students in terms of the project development.

In academic and language input, the students need guidance mostly during their thesis writing stage. They need particular guidance on when to stop data collection and analysis when to start drafting the thesis and how to structure it (Moses, 1992). Thus, the supervisors are expected and assumed to be guides (Cryer, 2000; Kam, 1997; Russell, 1996; Sheehan, 1993; Waite, 1994) and critical friends (Hockey, 1996; Sheehan, 1993). On the other hand, they should also be able to adopt flexible supervision strategies depending on the individual requirements which are influenced by the attributes of the particular student (Hockey, 1996; McQueeney, 1996). This is due to the fact that students are not homogenous but highly diverse in terms of academic ability, personality attributes, motivation and attitude. Hence, how supervisors respond to students will, in part, be conditioned by these different factors and applying the same rigid strategy for each student may not always work effectively (McQueeney, 1996). The supervisor should have skill in specifically in writing and gives constructive feedback to their thesis.

Managerial input consist the role of the supervisor to plan and structure the whole project and thesis. Moses (1992) argues that at each stage of the research progress, students are likely to need different forms of guidance. Hockey (1996) agrees with this statement and suggests that supervisors initiate a tight structure of control solely with the students whom they consider to be weak. However, research has found that strong and highly motivated students also demand such a structure. Conversely, with this kind of student, supervisors might need considerable latitude in order to express themselves intellectually. In this case, a relatively unstructured strategy might develop with supervisors being primarily reactive to student's demands. Thus, a supervisor is designated to facilitate the student's research development based on good resources offered by the institution (Ismail *et al*., 2014). Managerial input is crucial to ensure that a student will graduate on time.

Innovative and creativity input was introduced in this variable where (Weib, 2009) emphasized on enhancing innovation and creativity including entrepreneurship at all levels of education and training. Weib (2009) describe innovations as something new that may be a new product, a new service or a new solution to a problem. Innovations do not, however, always have to mean something which is completely new. Innovations can also involve the application of a solution familiar in principle within a new context. According to Eurpean Commission (2009) enhancing creativity and innovation has been highlighted as a priority until 2020. As the ability for innovation are to become key competences in TVET Malaysian government has allocated an amount of budget for innovation practice such as MySkills (Malaysian Skills) and ITEX (International Invention, Innovation and Technology Exhibitions) and in Europe for example, the year 2009 had been declared as the European Year of Creativity and Innovation. Stach and Stoger (2009) reported that creativity refers to the development of ideas to transform and restructure established and ingrained practices and products, carried by an impulse to find more satisfactory solutions than those which already exist. Therefore, a supervisor is hoped to implement creativity and innovative inputs into their supervision and research project.

## MATERIALS AND METHODS

The study applied quantitative research design using survey questionnaires. Total 360 sets of questionnaire were administered and returned. The participants of this survey were the technical and vocational-diploma students from four centers of Advanced Technology Training Center (ADTEC) in Malaysia according to the stratified random sampling. Initial contacts were made with the directors of the centers who were informed of the purpose of the study. Then, the researcher went to each center to conduct the data collection session. The questionnaire was measured with 25 items. A five-point scale ranging from "1 = strongly disagree" to "5 = strongly agree" was used to measure them. Figure 1 shows the factors for SIS that was identified from the

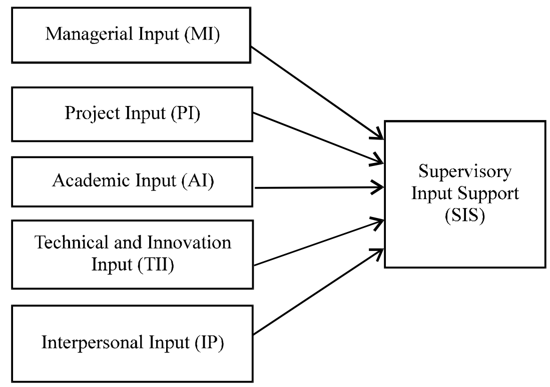


Fig. 1: Factor for supervisory input support

literatures (MI, PI, AI, TII and IP). These factors will be tested to see whether they are the suitable elements to foster SIS. The analysis was conducted through SEM by using AMOS Software.

## RESULTS AND DISCUSSION

The respondents of this study were the final year students in Diploma Program from four main ADTECs in Malaysia which cover the Peninsular of Malaysia. Most of the respondents are from the age of 21-25 with 91.4%. 5.6% aged below 20 and 2.8% are from age 26-30. Only one respondent ages above 30. Most of the respondents are male with 68.6% and female with 31.45%. Malay respondents depicted the large participation with 81.7% followed by others 8.3%, Indian 5.3% and Chinese 4.7%. Others category is for Bumiputera such as Orang Asli and ethnics from Sabah and Sarawak. Both chosen sectors were equally analyzed with 180 respondents each. The numbers of respondents from each of the institute was determined by stratified random sampling.

**Confirmatory factor analysis and construct validity:** Confirmatory Factor Analysis (CFA) is a special form of factor analysis. It is employed to test whether the measures of a construct are consistent with the researcher's understanding of the nature of that construct (Zainuddin, 2012). CFA has built upon and replaced older methods and analyzing construct validity. Hair *et al*. (2010) suggested that construct validity can be tested using convergent validity (the extent to which indicators of a specific construct 'converge' or share a high proportion of variance in common), discriminant validity (the extent to which a construct is truly distinct from other constructs) and nomological validity (is tested by examining whether or not the correlations between the constructs in the measurement theory make sense). The covariance matrix Phi (Φ) of construct correlations is

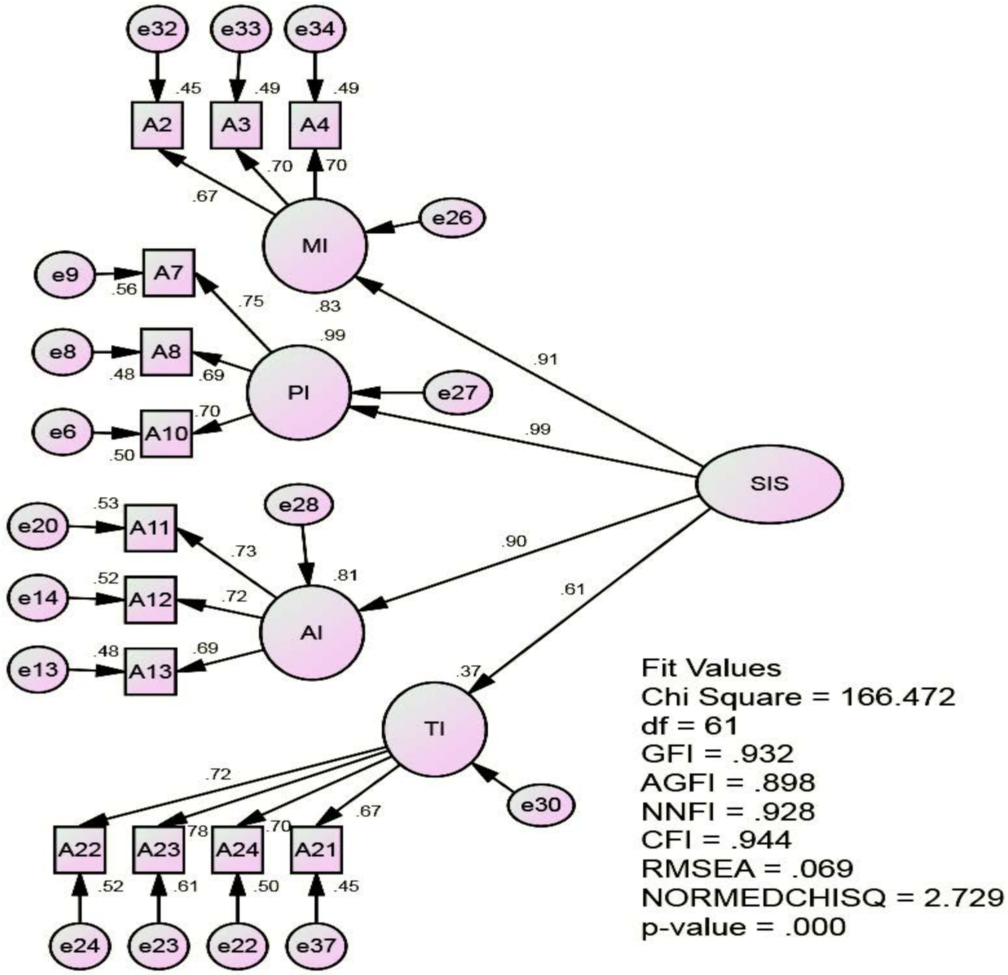


Fig. 2: Confirmatory factor analysis for SIS

useful in this assessment. In this research, CFA was tested using individual construct and construct validity was tested using measurement model in SEM analysis.

Hair *et al*. (2010) explained that there are three measures in convergent validity factor loading Variance Extracted (AVE) and reliability. Rules of thumb for convergent validity are as follows: standardized loadings estimates should be 0.5 or higher and ideally 0.7 or higher; AVE should be 0.5 or greater to suggest adequate convergent validity AVE estimates also should be greater than the square of the correlation between that factor and other factors to provide evidence of discriminant validity; and Reliability should be 0.7 or higher to indicate adequate convergence or internal consistency. AVE and CR must be calculated manually as AMOS Software did not provide the calculation.

The analysis for SIS was conducted for first order and second order CFA. The analysis of first and second order for SIS left only 17 items from 25 items originally. There was a problem to fit the Interpersonal Input in the SIS construct and it was decided that GOF is better when the sub construct is eliminated totally from the analysis. However, only 13 items met the AVE and model's GOF as in Fig. 2. The results indicated that the CFA model for SIS has sufficient and significant GOF at 0.05 level with AVE = 0.504 and 0.929.

The analysis of first and second order for SIC left only 17 items from 20 items originally as in Fig. 2. The results indicated that the CFA model for SIC has sufficient and significant GOF at 0.05 level with AVE = 0.520 and CR = 0.948. The results of CFA indicated that the four-factor model fits better with the data ($\chi^2$ = 166.472, df = 61; CFI = 0.944; GFI = 0.932; RMSEA = 0.069) than the five-factor model. The most important supports needed by

Table 1: The level of SIS

| Rank/Construct | N | Mean | SD |
|---|---|---|---|
| Project Input (PI) | 360 | 4.1978 | 0.58371 |
| Academic Input (AI) | 360 | 4.1422 | 0.59130 |
| Managerial Input (MI) | 360 | 4.0894 | 0.59271 |
| Technical and Innovation Input (TII) | 360 | 4.0728 | 0.63451 |
| Interpersonal Input (IP) | 360 | 4.0328 | 0.65234 |

the students as reported in the research are Project Input (μ = 4.198) and Academic Input (μ = 4.142) as in Table 1.

It is followed by managerial input (μ = 4.089), technical and innovation input (μ = 4.073) and interpersonal input (μ = 4.033). Since, the project supervision is a process of learning and teaching; developing the student and producing the research project/outcome as a social practice (Maxwell and Smyth, 2009), a supervisor is needed to understand the student's need and turn the process into a good outcome. According to Hodza (2007), supervisor must be willing to make adjustments in the relationship process to meet the supervisee's learning needs. This includes the consultation and appointment with the students. Holloway (1995) referred to this as the artistry of supervision. Prior to exploratory factor analysis test, factorability among the variables were determined. The assumption was made where there are at least some correlations amongst the variables so that coherent factors can be identified. Factorability can be examined via Kaiser-Myer-Olkin (KMO) and Bartlett's test of sphericity. The KMO is should be >0.5 and in this study, the KMO is 0.93 and Bartlett's test of sphericity is significant which is adhere with the rules. Thus, the EFA is recommended to be continued. Exploratory Factor Analysis (EFA) was conducted to SIS and especially for Technical and Innovation Input (TII) to test whether it is fit to be a dimension for SIS. TII is a self-developed items and new dimension introduced by the researcher based on the theories by Weib (2009) and Stach and Stoger (2009). The result of the analysis can be studied in Table 2. The items was factorized into 4 factors according to the loading value calculated.

Exploratory Factor Analysis (EFA) is used to identify complex interrelationships among items and group items that are part of unified concepts (Polit and Beck, 2012). The researcher makes no "a priori" assumptions about relationships among factors. Extraction method in the analysis was Principal Component Analysis (PCA) with Varimax rotation method. This is commonly used by many researchers. This rotation is an orthogonal rotation of the factor axes to maximize the variance of the squared loadings of a factor (Factor 1-4) on all the variables (A1-A3, B1-B3, C1-C3, D1-D4) in a factor matrix. It can differentiate the variables based on its factor. It extracts

Table 2: EFA for SIS

| | Component | | | |
|---|---|---|---|---|
| Items | 1 | 2 | 3 | 4 |
| A1 | | 0.796 | | |
| A2 | | 0.601 | | |
| A3 | | 0.688 | | |
| B1 | | | 0.560 | |
| B2 | | | 0.589 | |
| B3 | | | 0.767 | |
| C1 | | | | 0.671 |
| C2 | | | | 0.746 |
| C3 | | | | 0.736 |
| D1 | 0.718 | | | |
| D2 | 0.813 | | | |
| D3 | 0.775 | | | |
| D4 | 0.740 | | | |

Extraction method: Principal component analysis.; Rotation method: Varimax with Kaiser normalization; Rotation converged in 15 iterations

Table 3: The final dimension for SIS

| Dimension | Items |
|---|---|
| Management Input (MI) | Organizing: Arranges follow-up meetings with me<br>Directing: Provides me with information on relevant sources Monitoring: checks my progress |
| Project Input (PI) | Literature review: Tutors me on how to access information<br>Project proposal: Provides me with criteria for my project proposal Project development: shares his/her knowledge with me or refers me to an expert |
| Academic Input (AI) | Discipline/subject field expertise: shares the knowledge and experience with me<br>Assessing: Assesses my progress continuously<br>Evaluation: Provides input on the quality of my project |
| Technical and Innovation Input (TII) | Alert me on new and emerging technologies<br>Advises me to solve problems by the innovative use of materials Monitors me in design and manufacturing methods incorporation of innovative<br>Develop competitive new technological products |

the factor and set the loadings for each items either small or large value. The results make the process of identifying the variable becomes easier.

During the process of interpreting factor loadings, the 0.7 level corresponds to about half of the variance in the indicator being explained by the factor. The 0.7 can be considered as high. Normally, we seldom meet this criterion which is why some researchers, especially for exploratory purposes use a lower level such as 0.4 for the central factor and 0.25 for other factors. It can be said that loadings above 0.6 can be considered as high and those below 0.4 as low. In any event, factor loadings must be interpreted based on the theory, not by random cutoff levels. In a study by Morley ***et al.*** (2002), the loading was set to 0.4 as the minimum value. In the final analysis, the items were grouped into 4 components and thus explain the factors that contribute to SIS. Therefore, to examine the level of Supervisory Input Support (SIS), these 4 factors were deemed as significant in analyzing this construct thoroughly in this research context. Table 3 shows the dimension proposed and the items that passed the test with factor loading of 0.5 and above. This output can be used as a guideline by the supervisor during supervision process.

## CONCLUSION

The findings of this study lend effective substance in developing quality supervision with foci on strengthening supervisory input factor among students. The successful implementation of these inputs can be condensed to four factors: management input, project input, academic input and technical and innovation input. The implementation of this outcome into supervision practice will affect the student's learning activity and enhance the supervision practice. Supervisor and the management of the institution could make use of this finding into practice. Interventions which involved the collaborating of various stakeholders towards supervision outcome should be encouraged. It is hoped to provide a useful insight to both supervisor and supervisee.

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