ON THE IMPORTANCE OF PEER INSTRUCTION IN GROUP DESIGN PROJECTS

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ABSTRACT

This paper is focused on the importance of peer instruction in a collaborative design project and particularly on the knowledge transfer between fourth year (project managers) and second year (design engineers) students. A subtle change introduced in the last two years was that the prototype requirements for the second year teams were the same as the requirements that the fourth year project managers had to meet two years previously. This had a positive impact on the esteem of the project managers and increased their self-confidence allowing them to provide more relevant technical guidance to the second year students during the project. As a result, design teams were more likely to produce functioning prototypes, which also met a greater proportion of the design requirements. In order to understand the reasons behind the improved performance of the teams, the fourth year students were asked to assess their confidence and capability to manage design group projects in a survey. The results of this survey and its findings are presented in this work.

KEY WORDS

Group work, Design and build projects, Peer instruction, Standards: 5, 6, 7, 8

INTRODUCTION

Design and build projects are key aspects of the CDIO approach to teaching (CDIO Initiative, 2018). Often group projects are considered to present numerous advantages over individual projects since they allow transferable skills to be developed alongside technical expertise and management (Biggs, 2003). Group projects are also part of the accreditation requirements of professional bodies such as the Institution of Mechanical Engineers (IMechE, 2017), The Institution of Engineering and Technology (IET, 2017) and others. However there are also concerns about the use of group work in the engineering curriculum and especially related to the assessment of individual student's contribution to the project (Thompson et. al, 2015).

One of the limitations of project based learning is that the assessment is not straightforward and individual skills may get stifled or remain unrewarded. However, this method has a great influence on students' future learning, although effects in the short term may be unnoticeable. Participating in projects helps them to look at each other as sources of information and encourages peer learning. Mentoring is required to help them set-up and manage self-monitoring systems. A critical aspect is the review of the allocation of work to individuals and progress reviews at various stages. Bottlenecks in resource provision need to be addressed at the start along with disagreements between the members (Gibbs et. al., 1992).

Projects have a three-fold impact on student learning (Fry et al., 2014). First, they provide a means to introduce research culture in the undergraduate curriculum. Second, it encourages them to stay on as research students. And third, it emphasises the responsibility that the

learners have to take up for their own learning and knowledge building. Having projects as a part of the curriculum also promotes the link between teaching and research. The role of a supervisor subtly moves towards being a facilitator.

Engineering Design forms the core of all undergraduate curricula (Aerospace, Electrical & Electronic, General and Mechanical Engineering) in the Department of Engineering, University of Leicester, UK. The largest element of the Design curriculum is the second year 'Integrated Engineering Design' module, which is taught by means of a Design and Build group project. Second year students work in multidisciplinary design teams and apply their course specific knowledge to the design and manufacturing of an integrated system. A fine balance has been achieved between structured and unstructured nature of design projects. Although the specifications for what needs to be achieved are strictly defined, the concepts and design solution are not prescribed. As a result, every year, there is a plethora of innovative designs used by the groups for achieving the objective. Each design team is project managed by fourth year (Master's level) engineering students. Also associated with each team are: an academic staff member, technicians and a Visiting Design Professor (VDP). The academic staff member acts as a supervisor and provides technical advice to the team, and the technicians provide practical guidance regarding the electrical and mechanical aspects of the prototype manufacturing. The VDPs are senior industry leaders who provide high-level feedback to both design teams and project managers, and their role is approved and supported by the Royal Academy of Engineering (RAEng). Associating multiple personnel, with varied levels of experience, for mentoring the groups provides a broad base of skill set that remains available to the groups for consultation, and irons out any weakness of an individual supervising the group. It also makes the level of support offered quite uniform across the groups.

In the past, the students have been tasked with a different design project each year and the projects topics varied from sustainable energy to unmanned aerial vehicles (Chalashkanov, 2014). However, over the years some fourth year students have expressed concerns about managing projects that they have no technical expertise in. In order to assess the importance of this factor, in the academic year 2016-2017 it was decided to repeat the design task given to the students two years before. The implication was that the majority of the fourth year students would have done the same project in their second year of study. The only exceptions were students who had spent a year working in industry or studying abroad. The project topic was a model hovercraft, and the requirements specification was similar to the brief given to the students in 2014-15 with the exception of some minor technical details.

In 2014-2015 there were 24 design teams. Each team was required to produce a functioning hovercraft prototype by the end of the module and all prototypes were assessed by the panel of VDPs in a Design Competition. Only one out of the 24 teams managed to produce a fully functional prototype. The rest of the prototypes met the design requirements only partially. In contrast to the 2014-2015 design project, only one team produced a prototype which was not fully functional in the 2016-2017 design challenge.

The difference in performance between the two cohorts was attributed to the experience of the fourth year project managers. Because the majority of the fourth year students had previously worked on a hovercraft project (as design engineers in their second year of study) they were in a position to provide better technical guidance to the second year students in their team. In general they showed increased confidence in leading and managing the teams, which was also noted by the VDPs who assessed them.

In order to gain a better understanding of the students' perceptions and gather observations about the fourth year students' confidence and capability, the fourth year cohort was surveyed in the 2017-18 academic year. As before, the group project had a similar requirements specification to the project given to the students two years previously. The results of the survey and its findings are presented in this work.

METHODOLOGY

The fourth year project managers were asked to complete a questionnaire regarding their confidence and capability to manage design and build projects. The questionnaire was anonymous, however the students were asked to provide some basic demographic data in relation to their degree specialisation and previous experience. The questionnaire consisted of 11 questions in total. The first 3 questions were to establish the demographics of the cohort. The remaining questions were probing their self-assessed confidence and capability to manage engineering design teams and their perception of what skills are most important to a project manager. For the purposes of the study, confidence and capability were described as:

- Confidence – Someone who self-assesses as being very confident would feel comfortable approaching a problem or task, with little or no 'expert' support (e.g. from academic mentors).
- Capability – Someone who self-assesses as having a high capability would believe they had the necessary skills and knowledge to attempt a problem or task, with little or no additional tuition (e.g. from mentors or other resources).

The students were surveyed in a scheduled design session using paper questionnaires. The participation in the survey was on voluntary basis and each fourth year project manager attending the session was given a questionnaire. In total, 41 completed forms were collected from 51 students enrolled in the course, indicating 80% participation in the survey. The first question asked the students to indicate their degree. The majority of students, 24, were on the Mechanical Engineering degree, 9 – Aerospace Engineering, 4 – Electrical & Electronic Engineering and 3 – General Engineering. One student did not indicate their degree specialisation.

The second question asked the students to indicate if they have completed a year in industry or year abroad (both options are available to students who have successfully completed the first two years of their degree). 29 students had completed neither option, 2 students had studied abroad and 9 students did an industrial placement for one year. Again, one student did not answer that question.

The third demographic question asked the students to indicate the topic of the group project they had completed in their second year of study. 27 students had done a similar project to the one they were managing, 12 students had participated in a different project and two students did not indicate their prior experience with group design projects. For the purpose of analysing the results of the survey, the students who did not indicate their prior experience in group projects were grouped together with those who participated in a different project, giving a total of 14 students in that category.

Because of the small number of students enrolled on courses different from mechanical engineering, it was not possible to analyse the results of the survey in terms of degree specialisation.

RESULTS

Table 1 shows a summary of the responses of questions 4-7 in the questionnaire. These questions aimed to probe the fourth year students' perceptions about their own confidence and capability to manage the current design project and provide technical guidance to the second year students. Each question required the students to assess their confidence and capability between 1 and 5, with 1 being low confidence/capability and 5 being high confidence/capability. The mean scores for each question 4-7 are given in Table 1. The results in Table 1 are given for the cohort as a whole, and for two distinct sub-groups: students who have participated in a similar project before (Group A) and student who have done a different project from the one they are currently managing (Group B - the majority of the students in these category have done an industrial placement for one year).

The mean ratings are very close in both sub-categories. It should be noted that the number of students who did the same project in their second year as the one they are managing is nearly twice than the number of students who did a different project, which is also reflected in the results for the entire cohort. The overall results for the cohort are biased to the responses provided by the larger group of students.

Table 1. Mean responses from survey questions 4 – 7.

No.	Question	Same project (Group A)	Different project (Group B)	Entire cohort
4	Please indicate your **confidence** in managing this year's second year design project.	4.0	4.2	4.0
5	Please indicate your **capability** in managing this year's second year design project.	3.9	4.1	3.9
6	Please indicate your **confidence** in providing technical guidance to the second year students.	3.6	3.9	3.7
7	Please indicate your **capability** in providing technical guidance to the second year students.	3.9	3.9	3.9

Table 2 summarises the responses to questions 8 and 9 for the entire fourth year cohort. The majority (approximately 70%) of the students indicated that they feel both more confident and more capable to manage a similar project to what they have done in the past. 29% of all students expressed an opinion that the project topic does not make any difference, and only a small percentage of the students indicated that they would feel more confident managing a different project.

Table 2. Mean responses from survey questions 8 and 9. All students.

No.	Question	Similar project	Makes no difference	Different project
8	Please indicate whether you would have more **confidence** managing a project that is technically similar to or different from those you have participated in the past.	69%	29%	2%
9	Please indicate whether you would have more **capability** managing a project that is technically similar to or different from those you have participated in the past.	71%	29%	0%

The breakdown of the responses for the two sub-groups (Group A and Group B) described above is given in Tables 3 and 4, respectively. It is noteworthy that the responses to question 9 of both groups are effectively the same. However, there is a significance difference between Group A and Group B in their responses to question 8. 78% of the students in Group A indicated they are more confident managing a similar project to their prior experience and 22% indicated that the topic does not make any difference. The corresponding numbers for Group B are 50% - similar project, 43% - makes no difference and 7% - felt that would be more confident managing a different project.

Table 3. Mean responses from survey questions 8 and 9. Group A.

No.	Question	Similar project	Makes no difference	Different project
8	Please indicate whether you would have more **confidence** managing a project that is technically similar to or different from those you have participated in the past.	78%	22%	0%
9	Please indicate whether you would have more **capability** managing a project that is technically similar to or different from those you have participated in the past.	70%	30%	0%

Table 4. Mean responses from survey questions 8 and 9. Group B.

No.	Question	Similar project	Makes no difference	Different project
8	Please indicate whether you would have more **confidence** managing a project that is technically similar to or different from those you have participated in the past.	50%	43%	7%
9	Please indicate whether you would have more **capability** managing a project that is technically similar to or different from those you have participated in the past.	71%	29%	0%

Question 10 asked the students to rank the main strengths and weaknesses of their managers when they did their second year project. 30 valid responses were collected for the first part (strengths) of this question and 27 valid responses to the second part (weaknesses). The results are summarised in Figures 1 and 2 for all students. Because of the smaller number of valid responses, the survey data for Questions 10 and 11 was analysed in terms of the entire cohort. The data is given in actual number of student responses per category rather than percentages. The top three strengths, which the current fourth year students identified in their predecessors were: face-to-face communication (73%), general technical knowledge (67%) and personnel management (50%). The numbers given in the parentheses indicate the percentage of all responses, which ranked the specific skill in the top 3. The top three weaknesses were: electronic communication (56%), project specific technical knowledge (52%) and personnel management (44%).

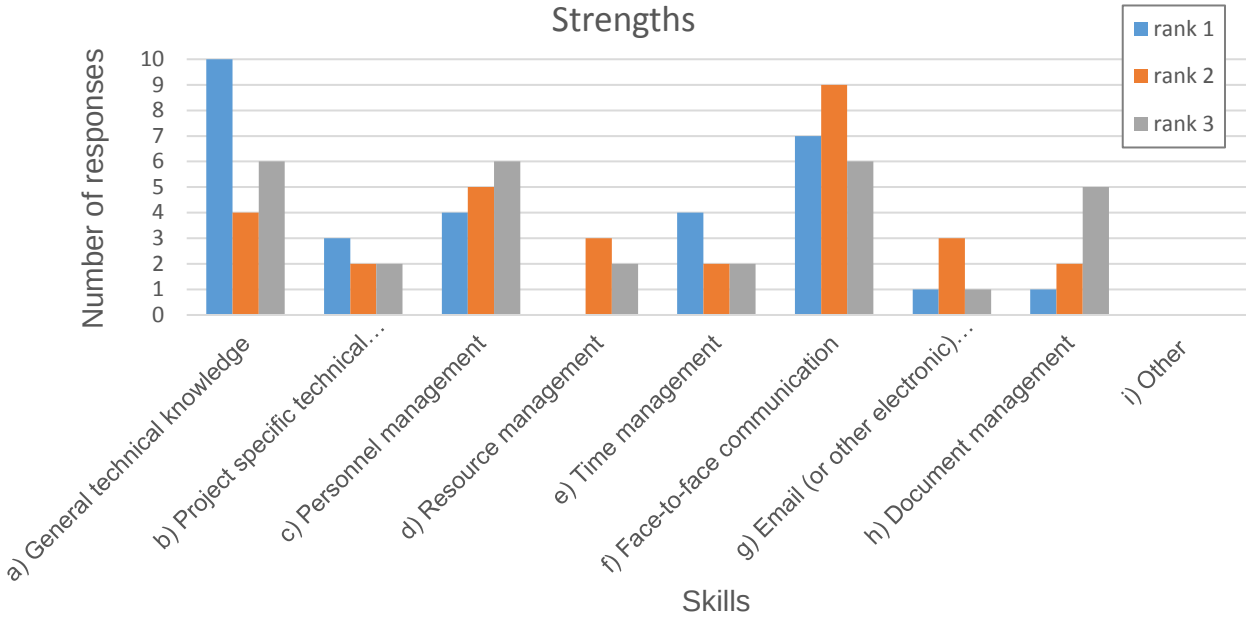

Figure 1. Summary of responses to survey question 10: In your opinion, what were the main strengths/weaknesses of the fourth year project managers when you did your second year project? Please rank the top three.

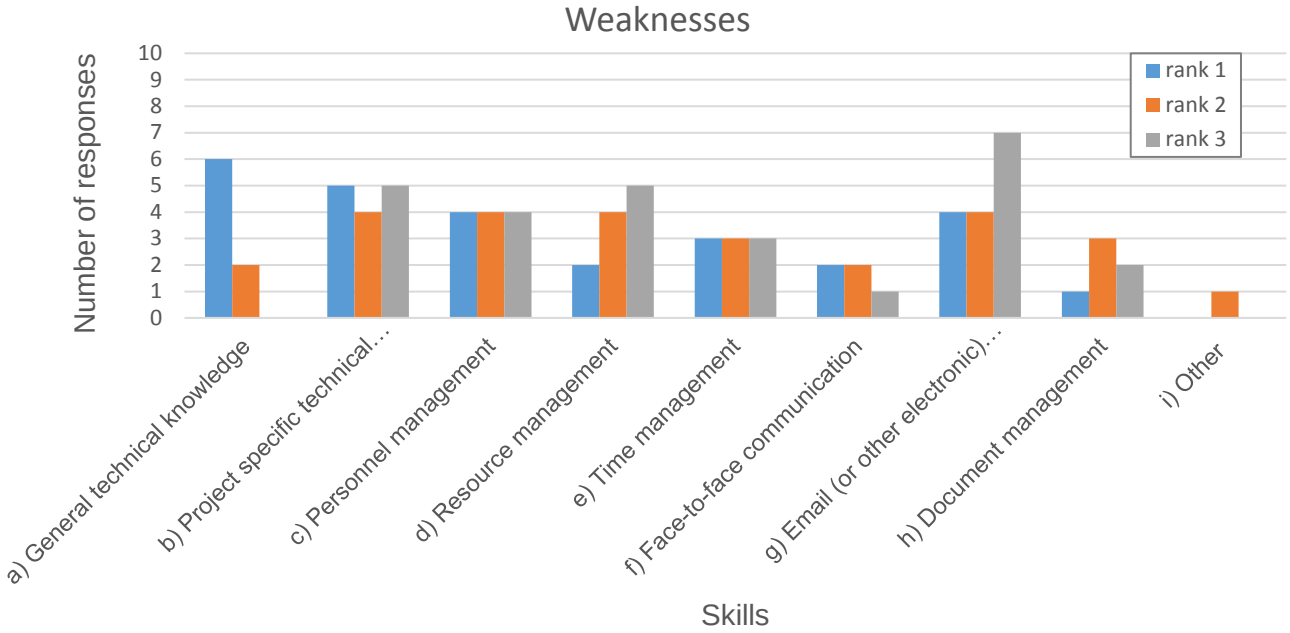

Figure 2. Summary of responses to survey question 10: In your opinion, what were the main strengths/weaknesses of the fourth year project managers when you did your second year project? Please rank the top three.

Question 11 probed students' perceptions about the most important skills a project manager should possess and what they consider to be their own greatest strength. The results are summarised in Figures 3 and 4. The number of valid responses in both parts of the question was 31. The students regarded personnel management as the most important skill. 94% of all responses identified this skill as important and ranked in the top 3. As equally important skills were highlighted: general technical knowledge, time management and the face-to-face communications. Similar results were observed for the students considering their own strength. However in this case 39% of the responses identified project specific technical knowledge to be their own strength.

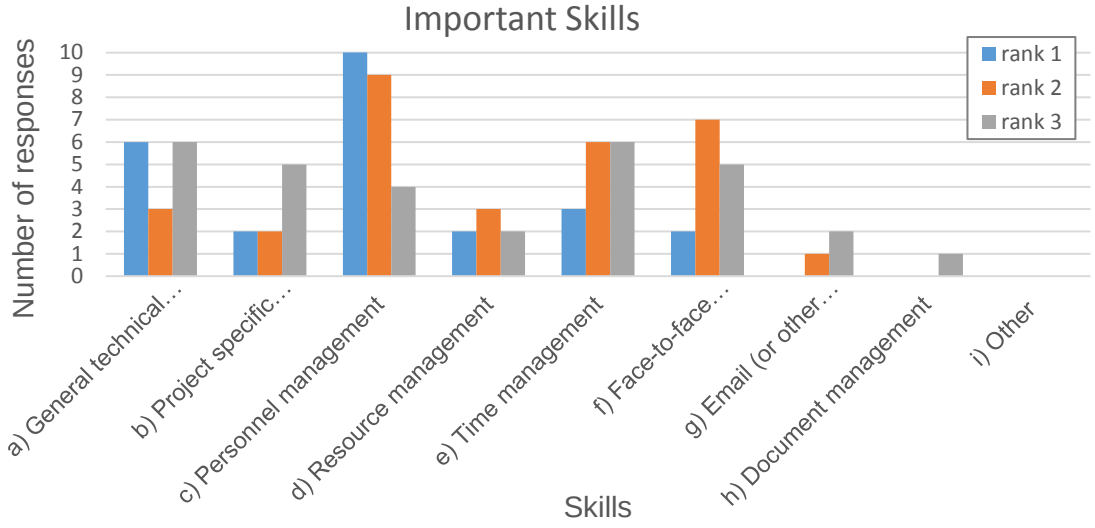

Figure 3. Summary of responses to survey question 11: In your opinion, what are the most important skills for a project manager to possess and what are your own greatest strengths as a project manager? Please rank the top three.

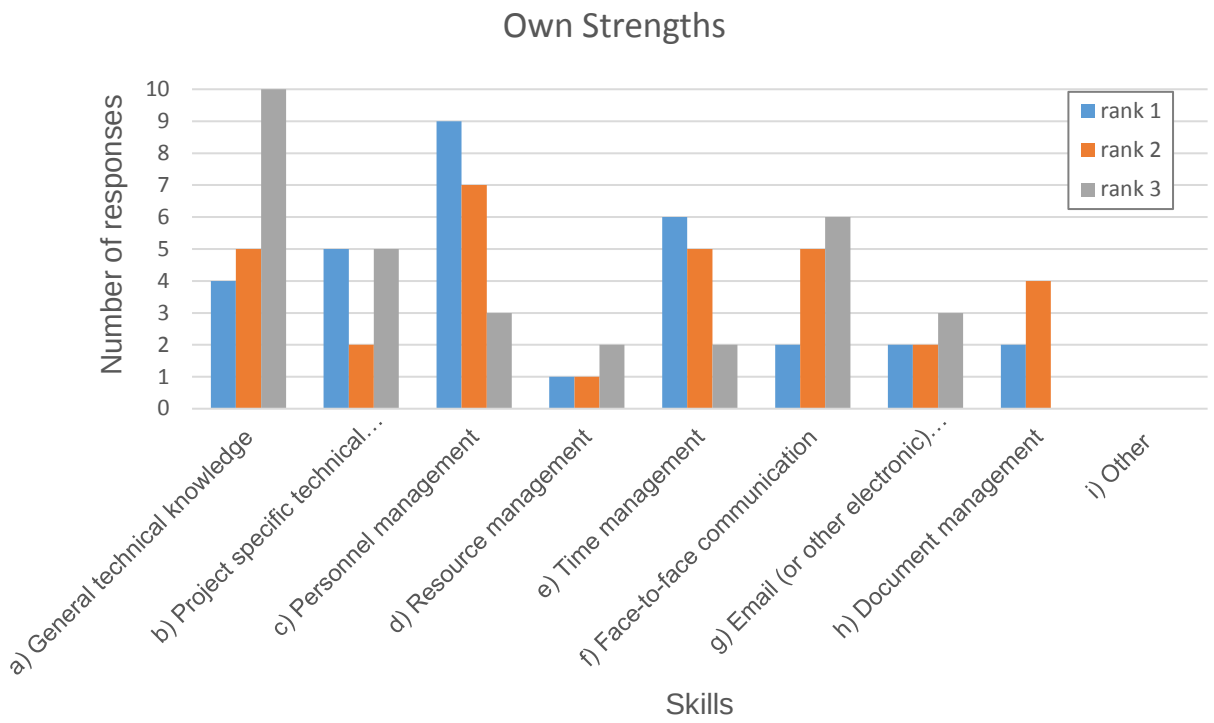

Figure 4. Summary of responses to survey question 11: In your opinion, what are the most important skills for a project manager to possess and what are your own greatest strengths as a project manager? Please rank the top three.

DISCUSSION

The results shown in Table 1 show no significant difference in the self-assessed confidence between Groups A and B, i.e. all students are almost equally confident about managing the current project. Group B indicated slightly higher confidence in both managing the project and providing technical guidance. However the difference is small and it is difficult to justify statistical significance of the results because the two groups are of different sizes (Group A is almost twice as large as Group B). The slightly higher levels of confidence could also be explained by the fact that Group B students had industrial placement experience, which seems to compensate for the lack of project specific technical knowledge that students in Group A would have.

The data given in Table 3 reveal that the majority (78%) of the students in Group A felt more confident and hence preferred managing a project where they possessed relevant technical knowledge. In comparison the students from Group B, who had done a different design project as second year students but had industrial experience seemed to draw their confidence from that experience and considered themselves sufficiently confident to manage any project. However the perceived capability to manage a project is exactly the same between the two groups, with 70% of the students preferring a similar project to what they had done in the past. It appears that industrial experience does not improve students' self-assessed capability to manage a different project, however it significantly improves their confidence.

Another objective of the survey was to gauge the understanding of fourth year managers of what they consider to be important skills that a manager should possess. Question 9 also helps to gauge what they felt was lacking in the managers of their design team when they

were second year design students. Of the 27 valid responses, 14% regarded that none of the weaknesses in their predecessors were important skills. 60% thought that one of the skills that their manager lacked was important and the remaining 26% thought that their managers lacked two of the important skills that they should have had. Interestingly, none of them thought that their managers lacked all three skills they consider to be most important. Of the 86% who thought that their managers lacked at least one important skill, only 11% considered the lacking skill to be most important.

Another interesting outcome of the survey was the fourth year students' perception of themselves in terms of possessing managerial skills that they consider to be important. Of the 31 valid responses, 42% felt that they have one of the skills that they consider to be important as an own strength. Another 42% perceived themselves to have two of the important skills and 13% believed they had all three most important skills that a manager should possess. Only one student's response indicated a lack of any of the top three most important skills as perceived by the respondent. Interestingly, 23% of the respondents considered themselves as having the most important skill that they believe a manager should possess. And overall, an overwhelming, 97% of the responses indicated that they consider themselves as having at least one of the skills that they perceive to be most important in a project manager. This finds a reflection in their confidence of managing the project, as is evidenced by the overall success rate for managing projects that they had already participated in.

CONCLUSIONS

As mentioned earlier, there was a change from one in 24 groups producing a fully functional prototype when the design project managers did not have project specific technical knowledge, to only one in 24 not being able to produce it, when the design project managers had that knowledge. Considering the proportion of working projects designed to specification as an indicator of success, it is quite evident that the second case is far more successful. On probing the fourth year managers regarding their perception of confidence and capability with respect to the project, they responded with a clear preference for managing a project that they have specific technical knowledge about. Also, one of the top two weaknesses they identified with their project managers, when they were members of the design team, was the lack of project specific technical knowledge.

This was the first time that the managers were surveyed in this module for their perception of confidence and capability. Some of the factors that drive this perception have been identified on the basis of what they consider to be as important strengths, weaknesses and skills for a manager. Personnel management, face-to-face communication, general technical knowledge, electronic communication and project specific technical knowledge have been identified by the fourth year students as important factors that drive their self-confidence and perceived capability of managing a project.

Based on this survey, thought was given to adjust the module and provide feedback to the managers regarding how to bolster the key factors identified and use them to their advantage.

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BIOGRAPHICAL INFORMATION

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