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Skill developed through field camps: A case study on surveying camp for civil engineering undergraduates

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CONTEXT

Survey work camps are used as an educational tool to improve practical skills through surveying in a real-life setting in different tertiary education levels such as training of technicians, technologists, and engineers. Different teaching, learning, and assessments (TLA) pedagogies are used in different camps. This research aims to investigate the contribution of real-life project-based surveying work camps to the development of different skills of civil engineering undergraduates. For this purpose, the skill development will be investigated by focusing on the development of course learning outcomes and the twelve graduate attributes of the civil engineering degree program composed by aligning to WA requirements.

PURPOSE OR GOAL

This research attempts to clarify the aspects

1. What kind of surveying skills were developed among students?
2. How the graduate attributes were strengthened by participating in the surveying work camp?

APPROACH OR METHODOLOGY/METHODS

Based on a questionnaire survey among students the skills developed were identified. Further using a factor analysis, the underlying skill components were identified.

ACTUAL OR ANTICIPATED OUTCOMES

Data from students who participated in the surveying camps revealed that students have developed basic surveying skills, some soft skills, and problem-solving skills leading to the achievement of some graduate attributes.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

The findings will provide insights into the effectiveness of surveying work camps as a tool to develop surveying skills and a number of key graduate attributes.

KEYWORDS

Surveying work camp, Graduate attributes, Skill development, Civil Engineering

Introduction

Many civil engineering curricula include land surveying considering its applicability to many civil engineering projects. This is generally delivered through courses that teach surveying fundamentals and key surveying techniques such as contouring and traverse surveying followed by a series of field sessions for the relevant surveying techniques. During the field sessions, students learn to use surveying instruments along with exercises for respective surveying techniques. Further, some degree programs include a separate surveying camp which is conducted as a residential camp spanning some time typically one to two weeks. Such field camps play a pivotal role in providing practical and hands-on experience to undergraduate students in civil engineering and can provide an immersive learning environment that bridges the gap between theoretical knowledge gained in classrooms and real-world application. However, these camps involve a huge amount of financial and human resources such as faculty members and the time allocation that could otherwise be used for a different learning experience. It is worth investigating about the surveying related other skills developed through the surveying camp.

The present research paper examines the skill development achieved through one such surveying camp designed specifically for civil engineering students. Initially the work aimed to see the effectiveness of surveying camp and on campus learning to develop surveying related skills. Secondly it is aimed to see what kind of surveying and other skills are developed during the camp. The study helps to identify improvement of skills. By employing a quantitative questionnaire, we aim to gather precise and measurable data regarding the progress made by participants in various surveying competencies. The questionnaire is designed to elicit responses about participants' self-perceived skill levels after the camp, providing valuable insights into their personal growth and progress during the camp.

Literature Review

According to the Washington Accord (WA)(*Accreditation Manual (Washington Accord) with Effect from 02.03.2023*, 2023.), the graduates of four-year engineering degree programs accredited are expected to possess a set of graduate attributes. These attributes categorize what graduates should know, the skills they should demonstrate, and the attitudes they should possess. International Engineering Alliance (IEA) has been refining these graduate attributes over the years and these are adopted by the signatories as examples to suggest outcomes-based accreditation criteria for the programs that are being accredited in their own countries. The key features of the graduate attributes are summarized in the following tables. The 2013 version of IEA has specified twelve such attributes which are Knowledge, Problem Analysis, and Design/ development of solutions, Investigation, Modern Tool Usage, The Engineer and Society, Environment and Sustainability, Ethics, Individual and Team Work, Communication, Project Management and Finance and Lifelong learning (IEA, 2013)(*Celebrating International Engineering Education Standards and Recognition*, 1989). According to the Accreditation Manual of the Institution of Engineers Sri Lanka (IESL), these have recently been reformulated as this into 11 attributes where Environment and Sustainability have been included as an integral part of some other criteria (The Institution of Engineers Sri Lanka, 2023) (*Accreditation Manual (Washington Accord) with Effect from 02.03.2023*, 2023)

These graduate attributes form a baseline for curriculum development where the courses are planned to ensure that graduate attributes are achieved. Further in the exercises such as curriculum or assessment mapping, the same is used as a reference to check whether the degree programs have been successful in producing graduates with the aforementioned skills. Thus, the effectiveness of each learning activity can be assessed in terms of their contribution towards satisfying one or more of the graduate attributes.

In addition, few researchers have identified the skills expected from engineering undergraduates. Park et al., (2022) studied and highlighted engineering undergraduate students' leadership efficacy development associated with such professional skills as self-awareness, global competence, ethical awareness, creativity, and teamwork skills. Results of their study indicated that there are positive associations among the five professional skills (e.g., self-awareness, ethical awareness, global competency, creativity, and teamwork Five professional skills (self-awareness, ethical awareness, global competency, creativity, and teamwork skills) impacted engineering leadership self-efficacy.

Muhammad et al., (2021) identified indicators that can measure students' employability skills and attributes. Their research model divided the skills into fundamental skills, personal management skills, and cooperative skills. The results of their study identified that the low value of communication indicators in the variable of fundamental skills compared to other indicators was due to the lack of foreign language communication activities in the learning process. Communication is a vital aspect possessed by students, especially in global-level competition. The study results were used to measure educational institutions to develop and improve low work skills indicators so that new graduates will better be prepared for work. Muhammad et al., (2017) described it as an effective approach of the learning environment via project-based learning in enhancing engineering professional skills through the Survey Camp Course among civil engineering students. Five elements of professional skills have been identified for observation, namely, communication, problem-solving, team working, leadership and modern tool usage. A mixed-method research methodology was utilized to observe the effectiveness of the implementation of a project-based learning environment in conducting the course and to assess students' professional skills development upon its completion. This implementation of project-based learning in conducting the Survey Camp course shows positive results in increasing the students' understanding about engineering surveying and developing engineering professional skills as required by the Engineering Accreditation Council.

Methodology

This study used a case study methodology, analysing the learning experiences of four batches of civil engineering students enrolled in the Surveying Field Project course to determine the skills they had acquired during the surveying camp. As per the present university practices questionnaire survey of this nature do not require the approval of university ethics committee. In this study, under the university procedure there is no mention regarding the ethics approval. The course is organized in such a way that during their two weeks of residential camp, students would be expected to be given the challenge to solve a real-life problem through the application of civil engineering knowledge. The process includes surveying field data taken using appropriate surveying techniques during the fieldwork. The course consists of a range of assessments including assessment of surveying skills, surveying knowledge and as well as decision making skills, problem solving skills, engineering knowledge through the solutions proposed for the assigned problems.

In order to identify the skills developed through the surveying camp questionnaire was conducted among students who have participated in this course. Through a pilot qualitative questionnaire survey (involved recent graduates), the list of skills that would be developed through a survey camp was created and this list was enriched by discussions with other academic staff with experience in similar camps. A questionnaire survey was conducted among student groups requesting voluntary participation. Among 120 of students' cohorts, 80 students completed the questionnaire survey.

The project tasks of the survey camp included comprehension of the civil engineering problem faced by a local community, propose appropriate civil engineering solution based on comprehensive engineering survey and other related data analysis and designs. The survey assessments were conducted to evaluate capability to conduct a real life horizontal and vertical surveys, details surveys and individual skills of instruments handling.

The survey consisted of two sections. Questions in section one required the participants to evaluate the effectiveness of different learning opportunities (namely on-campus learning activities and camp learning activities) to develop surveying-related skills among the students. Data collected through Likert scaled-based (1= Not effective at all, 2= Was somewhat effective, 3 = Was highly effective) questionnaires were analysed using descriptive statistics for this purpose.

The second section required the participants to evaluate the contribution of the surveying camp to developing 54 different surveying related and other skills using a 5-point Likert scale (1= Strongly Disagree, 2= Disagree, 3= Neutral, 4= Agree, 5= Strongly Agree). The date collected was analysed using descriptive statistics to identify which skills were developed.

Further, an exploratory factor analysis was utilized to investigate underlying factors of skill development. For this purpose, data has been tested with a reliability test with overall Cronbach

Alpha value of 0.990, Validity/ Sample Adequacy test with overall KMO (Kaiser -Meyer -Olkin) value of 0.887. There are 5 factors that identified the surveying skills for observation.

Limitations and Threats to Validity

The data used for the study was based on one case study surveying camp delivered in one department. The outcomes may only be generalized into courses that are delivered with a similar delivery approach and similar circumstances.

Result and Discussion

The questionnaire survey results are analysed under two categories,

a. Effectiveness of learning opportunities during campus and during the surveying camp for the development of surveying skills (theoretical knowledge and instrument handling skills).

The effectiveness of the student learning process within the campus and during the surveying camp, the participants' expression on the effectiveness of each learning opportunity was obtained for different knowledge areas. The effectiveness was checked for different aspects of theoretical knowledge and different instrument types. Further in order to judge whether the student learning process is more effective during surveying camp as against on campus learning, the participants' expression on the effectiveness of each learning opportunity was compared. Table 1 details the mean values and results of the test to compare the means.

Table 1: Mean effectiveness values for different surveying skills using different learning opportunities (on campus learning and Surveying camp learning)

	Surveying skill variable	Mean value for		Standard deviation for		
		on campus learning	Surveying Camp Learning	on campus learning	Surveying Camp Learning	Difference between means
Theoretical knowledge	Surveying Basics	2.84	2.89	0.37	0.34	NS
	Vertical control survey and detail survey - Leveling	2.80	2.86	0.40	0.34	NS
	Horizontal control survey and detail survey	2.85	2.91	0.37	0.27	NS
	Advance surveying (EDM etc)	2.61	2.69	0.54	0.51	NS
Surveying Instruments knowledge	Theodolite	2.49	2.50	0.59	0.57	NS
	Levelling Instrument	2.85	2.91	0.36	0.27	NS

	Total station	2.88	2.93	0.34	0.26	NS
	Advance surveying (EDM etc)	2.23	2.24	0.63	0.60	NS
Likert scale: 1- Not effective at all; 2- Was somewhat effective; 3 - Was highly effective NS - Mean values for effectiveness are not significantly different at 0.05 significance level.						

In terms of theoretical knowledge students showed both on campus learning and surveying camp learning to have a higher level of effectiveness to acquire theoretical knowledge related to surveying basics. The effectiveness of learning the levelling instrument and Total station were also high for both learning opportunities. However relative lower effectiveness was shown for leaning the Theodolite and other Advance surveying instruments such as EDM. According to paired sample T-test, p values for the significant difference of mean values were higher than 0.05 for all surveying skill variables. There is no significant difference between on campus learning and survey camp learning regarding theoretical knowledge and survey instrument knowledge variable.

b. Development of surveying and other skills during surveying camp

Participants rated their agreement for the development of 54 different skills during the surveying camp. The mean and mode values of agreement were calculated of these ratings. Further an exploratory factor analysis was used to identify the underlying factors related to this skill development. Reliability test, data adequacy tests and Bartlett's Test were conducted to ensure the appropriateness of the data set for the factor analysis. According to the results of reliability and sample adequacy tests, the Cronbach's Alpha= 0.991 and it is confirming that the data set satisfied the reliability requirement. Further the data adequacy was confirmed by KMO value=0.848. So, this data set satisfied the sample adequacy requirement. As the two requirements were satisfied, this data set matched for exploratory factor analysis. The p value is less than 0.05 at 95% level of significance. Therefore, it can be concluded that the correlation matrix is not identity matrix and there is relationship between variables.

Considering descriptive statistics of mean and mode values of Table 2, the students achieved the 53 abilities successfully except for the ability "Set up the GPS survey station and take measurements within the allocated time.". More time can be allocated in next surveying camps to develop this skill. The surveying camp has helped to develop both surveying related skills and other skills.

Table 2: Rotated Component Matrix and mean and mode values for skills development

Skill developed	**Rescaled and Component**					**Mean**	**Mode**
	1	2	3	4	5		
To take accurate measurements and data collection in outdoor environments	0.67					4.53	5
Understand applications of land surveying techniques	0.77					4.51	5

Understand the purpose and methods of traverse survey	0.78					4.51	5
Understand the purpose and methods of leveling work	0.82					4.56	5
Understand the calculations, errors in a leveling work	0.71					4.49	5
Understand the calculations, errors in a traverse survey	0.63					4.49	5
Set up the leveling instrument and take measurements within the allocated time	0.78					4.58	5
Set up the Theodolite and take measurements within the allocated time					0.62	4.13	5
Set up the Total Station and take measurements within the allocated time	0.72					4.46	5
Set up the GPS survey station and take measurements within the allocated time					0.86	3.51	3
Interpret and analyse survey data for accurate representation and mapping purposes						4.23	4
Represent survey outcomes graphically Ex: as plan and cross-sectional drawings						4.29	5
Identity and treat issues/ errors that may affect the accuracy of surveying measurements						4.24	4
Use survey data to calculate basic aspects Ex: areas, volumes, slopes, distances	0.62					4.43	5
Identify the information required for civil engineering decision using survey measurements						4.43	5
Set up and operate survey control points and benchmarks	0.67					4.49	5
Effectively use surveying software and tools for data processing and analysis				0.66		4.15	4
Conduct accurate land surveying and mapping in civil engineering projects						4.28	4
Collaborate with my team members to conduct fieldwork						4.48	5
Solve problems among the teams in conflicting times		0.69				4.38	5
Collaborate with my team members to conduct office work						4.48	5
Work on time pressure						4.54	5
Work to complete the project tasks						4.56	5
Take care of surveying instruments	0.62					4.54	5
Work long hours in the field and office		0.64				4.53	5
Work in unfamiliar out door environment	0.62					4.46	5
Assess the risks in field environment and work safely	0.67					4.51	5
Analysing and solving problems encountered						4.59	5
Presenting surveying findings and reports to audiences		0.60				4.50	5
Resolving conflicts, addressing challenges to surveying						4.43	5
Troubleshoot and resolve equipment issues						4.31	5
Communicate and provide clear instructions to team members		0.66				4.39	5
Effectively manage my time and prioritize tasks during fieldwork		0.69				4.41	5
Convey surveying instructions and tasks to team members clearly and accurately						4.41	5
Thinking critically and making informed decisions when faced with complex surveying problems						4.43	5
Motivating and inspiring team members to achieve surveying goals and objectives						4.44	5
Setting up and calibrating surveying instruments for accurate data collection			0.6			4.39	5
Accurately interpret and analyse surveying data for mapping and reporting purposes						4.4	5
Listen and respect the opinions and ideas of my team members during survey camp		0.66				4.49	5
Enhanced my skills in planning and organizing surveying activities to meet project deadlines		0.66				4.44	5

Making informed decisions and solving problems as a leader						4.44	5
Defend the decisions based on proper engineering calculations		0.63				4.43	5
Developed proficiency in allocating time and resources efficiently for different surveying tasks		0.66				4.48	5
Understand the purpose of civil engineering structures/ infrastructure for general public						4.39	5
Understand the social problems of general public			0.75			4.45	5
Understand the technical problems of general public			0.86			4.43	5
Understand the economic problems of general public			0.86			4.4	5
Understand the how the civil engineers can serve the general public			0.7			4.45	5
Propose suitable civil engineering solutions by comparing multiple aspects of a project			0.66			4.43	5
Understand theories of land surveying techniques	0.67					4.48	5
Plan a new civil engineering project						4.38	5
Execute field work in a new civil engineering project						4.44	5
Manage time in a civil engineering project						4.49	5
Work with general public			0.72			4.45	5
Percentage of variance explained	25	21	19	10	7		

Table 2 gives the five factors derived through the factor analysis. These factors were defined by considering the variables which has factor loading above 0.6. Together five factors explained 81% of the total variance. The 1st factor explained the direct application of surveying knowledge to aid civil engineering decision making to solve real life problems. This skill can aid the development of the first three graduate attributes (Felder & Brent, 2003). The 2nd factor explains soft skills, team working skills and management skills. These are also related to similar three graduate attributes discussed above. These skills can however be developed through the regular courses done within the campus. The 3rd factor revealed an important ability to serve the general public through the identification of different issues faced by the general public and by working with them. 4th and 5th factors described about usage of modern tools and other tools useful in civil engineering decisions making. Muhammad et al, (2017) identified five professional skills to be developed through the surveying camp which are, communication, problem-solving, team working, leadership, and modern tool usage. This study found similar findings along with factor 3 which is a new finding of this study.

Table 3: Factors identified and associated IESL graduate attributes

	Factor	Relevant graduate attribute (IESL)
1	Application of different engineering survey techniques create necessary information civil engineering decisions	Knowledge, Problem Analysis, Design/ development of solutions
2	Team work, communication, and resource management skills	Communication, Individual and Team Work, Project Management and Finance
3	Ability to serve the general public as a civil engineer	The Engineer and Society
4	Effective usage of tools for data processing and analysis	Modern Tool Usage
5	Efficient usage of modern surveying instruments	Modern Tool Usage(Felder & Brent, 2003)

Conclusion

This research aimed to understand the contribution of a residential surveying camp to develop surveying and other skills among civil engineering undergraduates. The present study identified that both on campus learning and surveying camp are effective learning methods for surveying skills development. The lowest effectiveness values (2.23 & 2.24) were reported for the skill development for advanced surveying instruments. Skills developed through the camp can be instrumental in achieving eight graduate attributes namely Knowledge, Problem Analysis, Design/ development of solutions, Individual and Team Work, Communication, Project Management and Finance, The Engineer and Society, Modern Tool Usage. Course administrator who considers new approaches to develop a range of graduate attributes using similar camps could benefit from findings.

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