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Integrated Land Use and Transportation Engineering Training Program: Fostering Team Work Among Students

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Abstract *- In recent years, the importance of integrated land use and the transportation system has received a lot of attention. Lack of knowledge on how land use and transportation systems interact and affect each other during planning for urban development could impact negatively the sustainable development of cities. Graduate students in Transportation Engineering are potential traffic, safety, and city planners. These graduate students, therefore, need to have fundamental knowledge on how land use and transportation interaction adversely affect the economy, environment, and social lives of people in a city. To achieve this, a three-month training programme on integrated land use and transportation was organized for 50 Transportation Engineering graduate students studying in various fields of Transportation Engineering at the Wuhan University of Technology. To foster team work among the students, they were asked to form groups. These groups were formed as male, female, and male-female. The student groups were assessed on three tasks (project undertaken, lab work, and classroom presentations) after they were taken through various land use and transportation modeling topics. The key finding of this study is that for all three assessment results, male-female groups achieved the highest average score and as well as the highest accuracy in their final project (travel demand model) task as compared to the other two gender groups. It is concluded that to promote innovation and creativity through diverse perspectives, group work involving gender mix should be encouraged among students. The entire training programme has also successfully achieved its objective.*

Keywords*- Graduate students, Land use, Team work, Transportation Engineering.*

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1. Introduction

Graduate students contribute to the development of cities in many ways. Their knowledge and skills acquired throughout the various level of education contribute to the sustainable economic development of cities and countries as a whole. Transportation plays a significant role in the economy of every country and has received a lot of attention because of its adverse effects. For about 4 decays ago, spatial planning policies have focused on land use and transport system as the two basic components of the urban development process [1]. To plan for transportation infrastructure or make a decision on land use development, it should be noted that, "transport planning decisions affect land use development, and land use conditions affect transport activity" [2]. According to [1] finding the optimal spatial organization of urban functions in conjunction with a balanced transport system is a necessary condition for sustainable urban development and mobility in modern cities.

Understanding influencing factors between land use and transportation is a fundamental requirement to the successful development of new urban areas, this will enable planners to tackle technical needs at the early stage of the planning process [3]. To understand the relationship between transportation and land use and solve the technical needs during the planning process, developing travel demand models in which land use is a fundamental influencing factor is required. Travel demand models used for predicting future travel demands are useful tools for evaluating land use and transportation impacts on both short and long-term horizons. Most cities in China are witnessing rapid urbanization and as a result, urban transportation is as well, being developed at a faster rate. Wuhan, a city located in central China, has been and remain an important hub connecting north and south, east and west of China for a long history. Wuhan is one of the populous cities in China and expanding very fast during the past two decades [4]. Wuhan, apart from the fact that it is the hub of China, the city is popular because of its numerous universities and student population.

Urban transportation does not exist without problems. Urban transport in any rapid urbanizing city globally would exhibit many similar transport problems such as rapid growth of private motorization, traveler dissatisfaction with public modes, worsening traffic congestion, traffic emission, and urban sprawling. Understanding the current theories behind successful integration of land use and transportation trends, and movement of people coupled with other socioeconomic factors like population growth is key to success in solving urban transport problems.

The above-stated background necessitated the inception of a graduate trainee programme on integrated land use and transportation to equipped graduate students from all areas of the transportation engineering field with the necessary knowledge. Furthermore, not only was the programme intended to provide students with knowledge on land use and transportation theories, but also to take them through various lab works involving the use of land use and transport modelling software, and to foster group work among the graduate students from different fields of transportation engineering. According to [5] “the current practice in engineering education increasingly entails team work and group projects. The ability to work effectively in team is considered by many to be an essential skill required of today's engineers which are claimed to be one of the most desired qualities of a graduate engineer”.

However, the main aim of this paper is to assess whether the programme has achieved its main objective of providing students with the fundamental knowledge on integrated land use and transportation system interaction. To achieve this, the graduate students were assessed on classroom presentation, lab works, and on a group, the project undertook, (travel demand modeling task). However, the success of the programme was determined by how well each group utilized their knowledge acquired with the land use data provided, to develop a four-step travel demand model. To foster team work among students, all projects were assigned in groups and student groups were categorized into three main gender groups (male only, female only, and male-female).

The rest of the study is organized into the following sections: In section 2, we present a brief review of literature on integrated land use and transportation and also on four-step travel demand modeling assigned to the students; section 3 introduces the methodology adopted in carrying out this study and in section 4, we present the results and findings of the study. The final section (5) presents the concluding remarks.

2. Literature

Land use and transportation interaction are not only regarded as having economic, environmental, and social impacts on cities but also, one that influences the location choices of most households. As a result, transportation and land-use models being developed in recent years are disaggregate in form [6]. Most land use and transport models are used to evaluate urban city developmental projects to make a preliminary policy decision. Recently, [7] developed an integrated land use transport model to assess the wider economic impacts of a transport infrastructure project in Wuhan city. They indicate that “the development and application of such an integrated model for the analysis of wider economic impacts should help decision-makers understand not only the “direct or immediate” impact of transport infrastructure on mobility, but also those “indirect or long-term” impacts on the distribution patterns of economic activities, corresponding land use, and resulting urban structure”.

Integrated land use and transport modeling software available includes but is not limited to PECAS, TRANUS, and MEPLAND [7]. However, in this study, our focus has been on travel demand modeling which only requires land use data as input (See Figure 1). Travel demand models are very important in assessing the supply and demand side of land use and transportation. Modeling travel demand is a challenging task, but one that is required for rational planning and evaluation of transportation systems [8,9]

Travel demand models also referred to as trip-based demand models are based on a four-step process therefore; they are technically known as four-step travel demand models [10]. The steps include trip generation, trip distribution, mode choice, or split which are used interchangeably in this study, and the final step is trip assignment [8,11, 12]. Figure 1 below shows in detail the four steps involved in conducting a four-step travel demand modeling task assigned to the participants in the training programme. Four-step travel demand has been the best for estimating traffic volumes as compared to other models such as regression. [1] found the prediction accuracy of the four-step travel demand model to be better than a regression model in their study. However, researchers have identified some limitations of the four-step demand model by proposing new methods of making the model prediction results more accurate, see the work of [14].

The terms “training” and “education” sometimes in both research literature and practice can be arbitrarily used. Whiles “education” is associated with in-class learning experiences, “training” on the other hand is said to be out of classroom learning activities or experiences [15]. In this study, training is defined as both in-classroom and out-of-classroom learning experiences or activities.

The intellectual potential of cities and regions is primarily reinforced by the growing population of students [16]. It is believed that graduate students have the talents to help cities and regions develop. [17] conducted a study in Canada and part of their title asks the question “Where does all the talent flow? Migration of young graduates”. This is an indication that graduate students have the talent cities are after. As a result, most cities are restructuring their systems to create an environment to retain or attract graduate students. [18] indicate that the inflow of graduates is often considered an important asset in achieving regional growth.

Working as a team is a necessity and graduate students develop their skill and competence of collaboration through various courses during their degree programmes which is helpful in their future careers [19]. [20] indicate that "employers consistently ask for good team-working skills, evidence of which is often provided by reference to group projects at university". For this and many other reasons, studies have been conducted on group works involving undergraduates [21, 22], and graduate [5] students. This study also intends to contribute to knowledge regarding graduate students' team work.

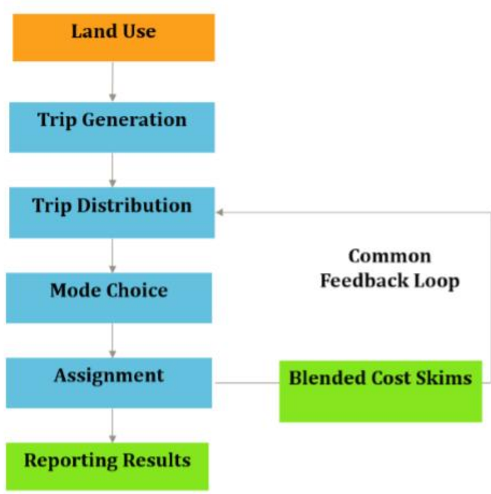

Figure 1. Four-Step Travel Demand Model

3. Research design

The data for the study was collected using a qualitative data collection instrument which includes observation and documents [23]. The study was conducted at the Wuhan University of Technology involving first-year graduate students. A three-month training programme was organized to introduce students from the field of Transportation Engineering to integrated land use and transportation engineering. To ensure that the intended purpose of the training programme is achieved, students were interviewed on various topics they were taken through and were also asked to answer questions during their class presentations. A four-step travel demand modelling project was assigned to student groups and the model results served as the document that was assessed. The results of the models developed by the students were compared with an existing model using the same dataset and procedure. The accuracy of each stage was observed and assigned an accuracy number.

The graduate students (50) from logistics, navigation, water transport, traffic safety, intelligent transportation system (ITS) background was asked to form 10 groups with each group not having a member less than 4 and for this paper, students were not informed that an external investigation would be conducted on their results based on gender groups but were also not restricted on any specific method for forming the groups. In the end, it was discovered that three main demographic groups were formed (male-only groups, female-only groups, and male-female groups) which was in the perfect direction for this study. Figure 2 below shows the conceptualized framework of this study presented in a form of a flowchart.

A descriptive data analysis is used to present the findings of this study representing results in simple tables and charts using Microsoft excel.

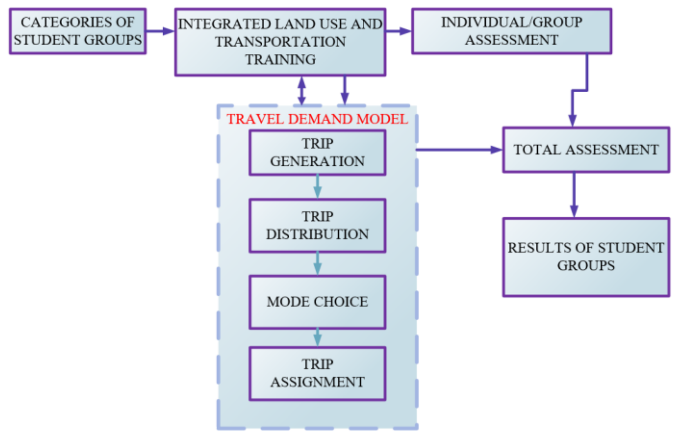

Figure 2. Flowchart of the Study

3.1 Model development and expected results.

The main task assigned to the students was to develop a conventional four-step travel demand model using a dataset provided. All the model parameters required for the task were provided except that students have to use their knowledge acquired during the training to identify and calculate other necessary model inputs that could affect the accuracy of the model. These inputs include zone-to-zone travel impedances (time or distance) based on various modes of travel which are used for calculating utilities in the mode split stage and car impedance used for trip distribution. TransCAD, which is a geographical information system (GIS) and transportation tool was the software used to accomplish the modelling task. Other GIS tools (Cube voyager, Tranus, and Emme) that support travel demand modelling were available but because of the friendly user interface of TransCAD, it was the best option for junior modelers.

The developed travel demand model included trip generation, trip distribution, mode split (choice), and traffic assignment stages. Since trip generation and traffic assignment steps required direct application of model parameters available in the modeling software, much emphasis is not laid on these two steps during the assessment. This is because the chances of each group getting these two steps accurately are high. However, the remaining two steps (trip distribution and mode split) required analytical thinking and application of what had been taught in the training to achieve accuracy. For our analysis of the accuracy of the model, we only discussed what we expected from the students on these two model development steps.

Trips distribution is the second stage of the four-step travel demand modelling process and its main purpose is to distribute trips generated from zone-to-zone based on travel impedance (time or distance). Hence, students were supposed to calculate travel impedance. These travel impedances are calculated from centroids of each TAZ-to-TAZ taking into consideration the identification number (ID) of each centroid. These centroid IDs were not made part of the road network and the students would have to integrate the centroid with the road network to achieve accuracy of their model result otherwise the results will be inaccurate. The trip distribution model involves a standard gravity model approach and the use of a travel time impedance measure. The mathematical formula for the gravity model applied in TranCAD software for trip distribution is given as:

$$Tij = Pi\frac{Aj\,Ftij\,Kij}{\sum_{j=1}^{n}(Aj\,Ftij\,Kij} \qquad (1)$$

Where,
- Tij= Trips from zone i to zone j
- Pi= Total trips sent from zone i
- Aj= Total trips received by zone j
- Ftij= Travel time factor for time between zone i and zone j (friction factor)
- Kij= Socioeconomic adjustment factor for interchanges
- n= Number of analysis zones

Mode split (Choice) uses utilities of various modes of transport to split person trips to each mode by trip purpose from zone-to-zone. Four main modes were considered in this study, private car, taxi, bike, and walk. Students were supposed to prepare various zone-to-zone matrices as an input to the utility function in the software to use. In the assessment, the total percentage of trips by each mode of travel calculated in the model developed by the students is expected to be equal to the already developed model. Any difference means students do not calculate the utility input matrices correctly. The nested logic model used is shown in figure 3.

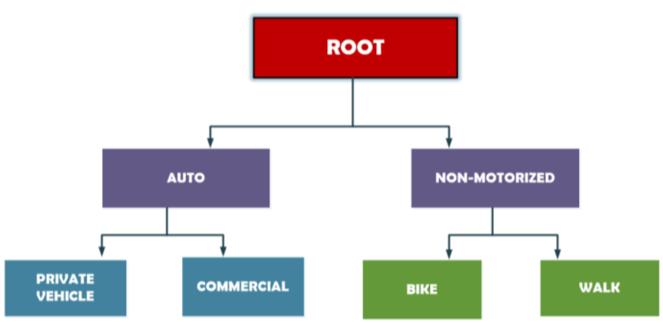

Figure 3. Nested Logic Model

4. Results and discussions

This section presents the results and the findings of the study and a brief comparative discussion is made between the student groups. First, we present the results of the modeling task assigned to the students and compare their accuracy level with the developed model which was used as a benchmark for assessment. First-year graduate students participated in the training programme. 73% were male and 27% female. Almost all Engineering jobs are male-dominated. This is because women who pursue careers in engineering, technology, and physical sciences are fewer than men [24]. Hence, male students represent the maximum percentage. As stated earlier in the previous section (3), the trip generation stage was not considered in our analysis in this study because its process was well-defined and easy to undertake. Moreover, all model parameters were provided and students do not have to think beyond what they were provided with to complete that step.

The reason being that any mistake at the first step would completely affect the entire model development process and also because all input variables were also available. This was also done to allow the students to concentrate on how to solve the problem of trip distribution and mode split input variables. The results of each group from the trip generation turned out to be accurate when compared with the existing model results. The results include trips produced and attracted from zone-to-zone based on three main trip purposes (Home-base-work (HBW) trips, Home-base-others (HBO) trips, and None-home-base (NHB) trips) and were perfectly balanced as well by each group.

Figure 4 below shows the graphical representation of trip distribution results of the groups and also that of the existing model. For simplicity and time, only average trip length distribution(ATLD) results by HBW trips are shown. An ATLD of the existing model estimated 18 minutes for HBW trips which were used as a benchmark. However, the male-only group estimated 15, female-only 13, and male-female group 19. It was found that none of the groups estimated the exact. However, the male-female group achieved model estimation accuracy higher than the other two groups if a margin of + or – 10 errors is acceptable. What could account for the difference in ATLD accuracy is a disparity in friction factors estimated by the groups. However, the student groups demonstrated a high level of understanding of the topic of trip distribution.

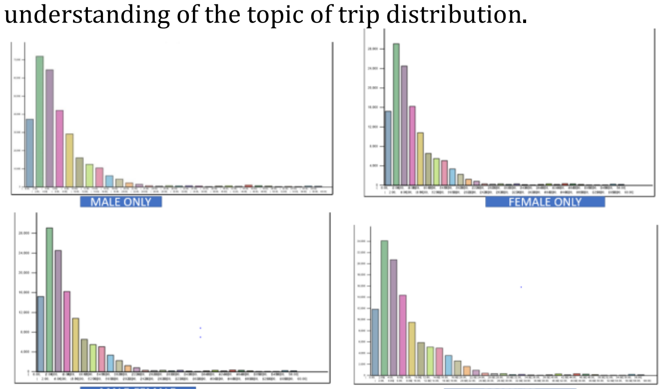

Figure 4. Trip Distribution Model Result

In Table 1, we present the mode choice result by trip purposes estimated by each of the student groups. The main modes considered in the modelling task are auto (private vehicle and taxi) and non-motorized modes (bike and walk) which were elaborated on in section 3. The number and percentage of the mode chosen by travelers by trip purposes are important to city planners and stakeholders to make informed decisions on planning for transportation infrastructure.

The results revealed that for HBW trips by car (Private vehicle), female groups predicted the percentage more accuracy followed by male-female groups, for the taxi, none of the groups accurately predicted the exact value. For bike mode, male groups predicted the exact percentage, followed by male-female groups. Male-female groups predicted the percentage of walk mode for all the three main trip purposes more accurately compare with the rest of the other groups. On average, we could conclude from the results that the model developed by male-female groups was accurate in estimating trips by all the transport modes. The disparity, on average, between the results of the student groups compared to the observed were low indicating a good knowledge and skills of the students on this step. This is a great indication that learning has taken place and also revealing the strength of team work.

The trip assignment module is the last and final stage of the four-step travel demand modelling process. It is the stage that reveals the travel demand on the transport network. With the results of the trip assessment, the planner or the traffic engineer could identify volume to capacity ratio on each link, and also get information such as travel time, congested speed, total flow on each link, etc. This step uses the total trips by modes from the mode split module as an input. Before the trip assignment step is carried out, students are to convert the persons trips into vehicle trips after the mode split stage by applying vehicle occupancy rate and then change the production-attraction (P-A) trips to origin-destination (O-D) trips. Once a student group misses any of the steps, the assignment results would be inaccurate. Figure 5 below shows the assignment results of the groups.

Table1. Mode Choice Results

Modes	**HBW (%)**				**HBO(%)**				**NHB(%)**			
	M	F	M-F	O	M	F	M-F	O	M	F	M-F	O
Car	12	15	16	15	11	20	20	18	20	21	17	16
Taxi	10	8	8	9	13	7	8	13	11	10	10	9
Bike	27	32	26	27	29	26	25	24	23	22	22	24
Walk	51	45	50	49	47	47	46	45	46	47	50	51

*M, F, F-M and O, are Male only group, Female only group, Male-female group and Observed respectively.

Male and female groups might have missed the above-explained steps and that had a significant impact on their trip assignment results. As compared with that of the benchmark, the results of male and female groups showed that the majority of the road link is congested whereas the thematic results from the benchmark model showed otherwise. The results of the male-female groups were more realistic and a replica of the benchmark model though significant differences were observed.

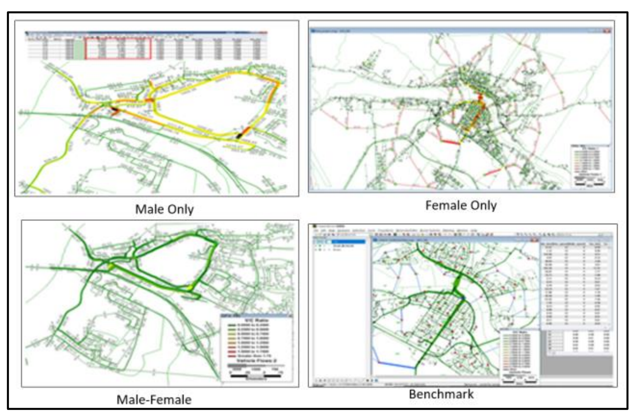

Figure 5. Trip Assignment Results

In Table 2, we show the accuracy of the entire four-step travel demand model developed by the 10 groups of the students who participated in the training programme. An accuracy scale was used to determine the level of accuracy starting from 1 to 5. 1 representing the highest level of accuracy and 5 representing the low accuracy level. The closer the number to 1, the higher the accuracy level and vice versa. Also, a total average score of students after the entire training programme is represented to show the success of the programme. The average scores were calculated from the various marks obtained during the whole training programme including classroom presentations, mini lab works, and travel demand modeling task.

Table 2. Model Accuracy Result and Average Total Assessment Marks

No. of Groups	Group categories	TG	TD	MS	TA	TAS (%)
1	M	2	3	3	4	76
2	F	2	3	3	3	79
3	M	1	2	3	3	81
4	M-F	1	2	2	1	92
5	F	1	1	3	3	79
6	M	2	2	3	3	84
7	M-F	1	2	2	2	89
8	M-F	2	1	2	1	92
9	M	1	2	3	3	83
10	M	2	1	4	3	82

*M, F, F-M and O, are Male only groups, Female only groups, Male-female groups.
* TG=Trip generation, TD= Trip distribution, MS=Mode split, TA= Trip assignment and TAS= Total average score

All the 10 groups achieved a high level of accuracy for the trip generation module because the required model parameters were all provided, however, some disparities could be observed among the gender groups. The trip distribution stage was a bit challenging for some of the groups however, a satisfactory level of accuracy was obtained. On the other hand, the mode split-step became a bit challenging for most of the groups due to the number of variables that had to be prepared as an input to the model. Preparing data for utility functions for each mode required analytical thinking and cautiousness. Furthermore, any error during the trip distribution stage will inevitably have a significant impact on the mode split which means that short trips would be done by bike or walk modes hence if the trip distribution model does not estimate the observed trip lengths, then mode split results would be automatically affected. This has affected the mode split results of almost all the groups except for a few that had their trip distribution step accurately completed. It could be observed that only 4 groups representing 40% of the groups had their trip assignment stage accurately undertaken. This indicates that the above-described process might have been escaped which accounted for the low level of accuracy. The result shows that only male-female groups achieved high accuracy at this level.

As indicated earlier, we wanted to find out whether the main purpose of organizing the training programme achieved the objective of providing these first year graduate students in transportation engineering with the fundamental knowledge on integrated land use and transportation system interactions. A series of assessments were carried out to evaluate the success of the programme which includes assessing the participants through classroom presentations, asking them questions about the topics after lectures, lab works, and group projects. About 4 lecturers assessed the students and their average scores after the entire training programme are shown in Table 3. With a minimum average score of 76%, we can conclude that the programme has significantly equipped the participants with the fundamental skills and knowledge on integrated land use and transportation system.

Figure 6 shows the disparity in the overall assessment made based on gender groups. Male-female groups have achieved the highest level of accuracy in all the three main categories of assessment used in this training programme. This indicates the strength of collaborative effort of students working together as a team especially when both genders are involved. From this result, we could conclude that students' team work involving both genders should be encouraged.

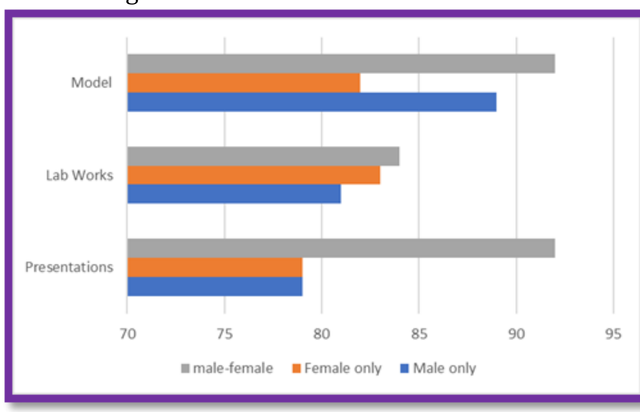

Figure 5. Overall Assessment Based on Demographic (Gender) Groups.

5. Conclusion

In this study, our main aim is to find out whether the integrated land use and transportation training programme organized for graduate students from various fields of Transportation Engineering has achieved its objective of providing these students with fundamental knowledge on integrated land use and transportation. We further explore how demography (gender) groups could influence team work involving graduate students' projects. To successfully undertake any engineering project, a collaborative effort is required and this has been the main motive for allowing students to undertake the project in groups to instill in them the spirit of collaborative attitudes and team work. Team work provides room for idea sharing and interaction. Not only does team work ensure the active involvement of all members, but in the end promotes the accuracy of product output. Above average, each graduate student group has achieved a certain level of accuracy in their modeling project that is encouraging and has reiterated the strength of collaborative efforts and team cohesion. Furthermore, from our findings, student groups that were formed based on gender mix (male-female groups), achieved higher accuracy in their modeling task as compared to the single-gender groups.

Team work has its advantages and disadvantages but one that is formed on gender mix could provide room for achieving higher output results and worth encouraging among students. Finally, innovation and creativity can be promoted by diverse perspectives in science through fostering collaborative work, and since males and females have different ways of perceiving things, the group works involving gender mix positioned themselves at a level of achieving a higher innovation and creativity for accurate output results.

The findings showed that at the end of the training programme the students acquired the knowledge and skills expected and also, the program has laid a strong foundation for those that are majoring in land use and transportation engineering. This was possible because, to actively involve each student in the training programme, a specific task apart from that of the group work, was assigned to ensure that each student actively participated in the programme. This made it also possible for each student to acquire the fundamental knowledge and skills from the programme. The programme was also successful because of the available diverse-knowledge of experts that took the students through the three-month training programme.

The limitation of this study is that the steps involved in the modeling task assigned to students were well-defined modeling approaches that limit the creative thinking abilities of the student groups.

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