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Managing Transportation for Sustainable Built Environment By Developing A Traffic Systems Management Course

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Abstract

The paper presents the development of a traffic systems management course aiming to prepare graduates to deal with the emerging rapid changes and challenges in urban travel demand and supply in the Palestinian territories. The paper also shows how the course prepares graduates to adapt the global shift in philosophy in dealing with the traffic congestion towards improving the efficiency of existing facilities. The course trains the students to design and evaluate low-cost, short-term, and quick-to-implement strategies for enhancing the traffic conditions and facilitating the achievement of sustainable built environment.

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1. Introduction

Traffic congestion and the resulting deterioration of the built environment quality have been observed and raising concerns at the centres of the urban areas in developing and developed countries alike [1]. To remedy such problems, a trend has emerged to develop traffic systems management techniques and solutions to implement the most effective solutions, taking into consideration the existing prevailing constraints, especially those related to limited space, capacity, and financial resources. This has resulted in a world-wide shift in philosophy in dealing with the traffic congestion problems from adding capital-intensive new facilities to options

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aiming to improve the efficiency of existing facilities through low-cost Traffic Systems Management (TSM) strategies.

The Palestinian Territories have witnessed significant increase in urban travel demand after the establishment of the Palestinian National Authority (PNA) in 1994. This increase was faced with limited development in the municipal transportation infrastructure, mainly due to the constraints of the prolonged Israeli occupation since 1967, and due to the lack of funding resources. With the assistance from the World Bank and the donor community, the PNA started in 1995 a number of TSM studies aiming at enhancing the traffic conditions and facilitating the achievement of sustainable built environment in the Palestinian Territories [2-5].

This paper presents the engineering educational sector quick response initiated by the Department of Civil Engineering at An-Najah National University to tackle the mounting traffic related problems impacting the sustainability of the built environment. This is reflected in the design of an undergraduate elective TSM course in 1995/1996 to assist the official institutions, municipalities and consulting firms by preparing graduates who can participate in the efforts to develop, design, implement, and assess TSM alternatives.

2. The Motivation and Need for Traffic Systems Management Course

Throughout the decades of occupation, the Israeli authorities did not implement major developmental projects, including transportation infrastructure projects, aiming to serve the Palestinian population all over the Palestinian Territories. This is also applicable in the municipal areas, which were in general administered by the Palestinians, where limited development in the transportation infrastructure has been witnessed as well. This is merely due to the constraints set by the Israeli occupation of Palestinian territories and the lack of the financial resources.

As identified by the World Bank mission assessing the immediate developmental and remedial needs on the eve of the establishment of the PNA, improving the traffic environment and rehabilitating the road systems within the urban areas were given a high priority [6]. Therefore, the PNA decided to start preparing TSM plans to satisfy the needs to relieve the mounting traffic congestion and to enhance the sustainable traffic and environmental conditions in Palestinian cities. During the period 1995-1999, international and local consulting firms joined the efforts to conduct TSM studies for ten urban areas in the West Bank and Gaza Strip [7].

During the course of the preparation of the TSM studies, there has been a lack of trained engineers who could work with the local consulting teams, or participate in the municipal and ministerial counterpart teams. This had induced the leading Civil Engineering Department at An-Najah National University to respond by developing an elective course especially designed with the aim to educate and train senior civil engineering students. The course was designed as a response to the need to supply the graduates with the necessary knowledge and training in managing the urban traffic system for sustainable built environment.

Assessment efforts were carried out to identify and highlight the TSM needs. These efforts were led by faculties and professionals who participated in the local TSM studies and who were exposed to the international experience in this field. The outcome of the assessment identified the need to develop a course that would not only give the students the basic theoretical knowledge of the various TSM strategies, but also to be more practically oriented. The course development specific needs were identified through involving the Palestinian Economic Council for Development and Reconstruction (PECDAR), the official Palestinian body that administered the TSM studies, along with the municipalities, which were the studies beneficiaries.

3. Course Development Objectives and Intended Learning Outcomes

The initial course development objectives as was stated in the first course outline prepared during the academic year 1995/1996 indicated that the course objectives were to provide the students with the necessary training in the management of the various types of traffic systems including Central Business District (CBD)

streets and junctions, residential area streets, arterials and freeways, as well as in the management of the various modes within the traffic systems including public transportation and pedestrians. Therefore the objectives concentrated then on providing the students with the in-depth knowledge and proper training in managing the supply side of the traffic system to achieve better overall outputs of the available roadways networks at reasonable costs.

Over the years, the course development objectives were revised to provide the students with the necessary knowledge and training in managing the demand side of the of the transportation system, as well as in pricing of transportation systems. Thus more considerations were given to satisfy the objective of achieving proper integrated knowledge and training to manage the transportation systems.

With the recent decision made by the Faculty of Civil Engineering at An-Najah National University during the Spring semester of the academic year 2010/2011 academic year to comply with Accreditation Board for Engineering and Technology (ABET) requirements, the course objectives were restructured. In addition to objectives stated previously, the proposed objectives concentrate on providing the students with practical training of traffic systems management though project-based approaches where students practice with assignments and projects that are oriented toward the application of the concepts studied in the context of the Palestinian territories. The Intended Learning Outcomes (ILOs) identified in the most recent course outline for the course taught during the Spring Semester of 2011/2012 include the provision of students upon graduation with abilities to:

- Apply knowledge of mathematics, science, and engineering in the management of the various types of traffic systems.
- Collect, analyze and interpret traffic data and related roadway factors and issues of concern, and use the techniques, skills, and modern engineering tools, in the management of traffic systems.
- Prepare designs or design modifications related to roadways and traffic systems and their components (e.g., surface streets, intersections, public transportation, parking), considering the impact of the resulting engineering solutions in an economic, environmental, and societal context, to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, sustainability, and safety, reflecting professional and ethical responsibility.
- Identify, formulate, and solve traffic systems management concepts and problems related to improving flow on streets and intersections, and understand contemporary issues in traffic systems management.

While Table 1 summarizes the engineering course learning outcomes, as identified by ABET,

Table 2 illustrates how the course achieves most of ABET outcomes. This is consistent with the expectations related to the objectives and learning outcomes of a senior course that are specialized and practical in nature.

Table 1: Intended Learning Outcomes as identified by ABET (Engineering Accreditation Commission, 2010)[8]

No.	ABET Intended Learning Outcomes	ABET Code
1	an ability to apply knowledge of mathematics, science, and engineering	A
2	an ability to design and conduct experiments, as well as to analyze and interpret data	B
3	an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	C
4	an ability to function on multidisciplinary teams	D
5	an ability to identify, formulate, and solve engineering problems	E
6	an understanding of professional and ethical responsibility	F

7	an ability to communicate effectively	G
8	the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	H
9	a recognition of the need for, and an ability to engage in life-long learning	I
10	a knowledge of contemporary issues	J
11	an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	K

Table 2: Mapping between the ABET Outcomes and the Assessment Tools

Assessment Tool	ABET Intended Learning Outcomes										
	A	B	C	D	E	F	G	H	I	J	K
Exams	■	■	■	■	■	■	■	■	■	■	■
Assignments	■	■	■	■	■	■	■	■	■	■	■
Projects	■	■	■	■	■	■	■	■	■	■	■

4. TSM Course Design and Contents

The design and development of an undergraduate elective course on TSM is illustrated here. The course was originally designed benefiting from the local experience where TSM projects had been implemented in ten Palestinian urban areas during 1995-1999, while considering the international experience in the TSM field. The challenge was to develop a TSM tailored course with special emphasis on the developing countries and specifically for an emerging economy.

The Intended Learning Outcomes and Competences illustrated in the previous section, guided the design of the course to be oriented towards providing the students with in-depth knowledge and practical training to understand, examine, suggest and implement measures to reduce or alleviate traffic congestion and improve safety and environmental quality. Despite the fact that the course was designed highlighting of the necessity to give the students the basic theoretical knowledge for the various TSM strategies, the course is being developed to have highly practical value. The practical side of the course is met by getting municipalities involved in the selection of the projects and through continuous interactions, the course served also as a platform for interaction with the municipalities and as a potential training location and even future career opportunities.

The course contents design was performed through the selection of relevant issues to be covered and the practical projects to be considered. Students are trained to study, evaluate, propose, and test measures to reduce traffic congestion, improve safety, and promote sustainable environment. Furthermore, they are trained to manage and improve the efficiency of traffic systems supply and demand at reasonable costs.

The course is divided into ten modules, where each one of these modules has emphasized one TSM aspect, but within an integrated approach. The following is a brief description of these modules

- Introduction to TSM: This section explains the concept of TSM and its processes. It also introduces demand-oriented and supply-oriented transportation solutions.
- Traffic System Evaluation: This section describes different methods of data collection and analysis, traffic studies, environmental and sustainable studies, cost-benefit studies, and infrastructure asset performance and evaluation techniques.
- Street and Intersection Management: This section describes the use of streets from different road user’s perspective. It also introduces some of the street management approaches, especially CBD streets and

residential areas streets, and explains the difference between these approaches, and identifies the suitability and applicability of each. Furthermore, it explains the geometric as well as traffic control intersections enhancement features, signal optimization and coordination approaches and the effect of different solutions on traffic, pedestrians, and environment.

- **Public Transportation Management:** This section is highly detailing the interaction between infrastructure, operations, and ridership. It identifies the challenges associated with capacity-constraints and the demand-constraints in transportation systems, and the role of public transportation meeting these challenges, and its significant role in advancing the sustainable traffic systems.
- **Traffic Restraints:** This section describes the different parking facilities and the common parking management practice, as well as establishment of pedestrian areas, and vehicles restrictions in the congested CBD areas, and truck restrictions. This section introduces transportation pricing approaches as tools towards managing and restraining traffic.
- **Travel Demand Management:** This includes introducing approaches to manage travel demand by changing the behaviour of the travellers, introducing changes to work hour patterns and schedules, and encouragement of non-motorized transportation such as walking and cycling.
- **Environment and Safety Improvement:** This section emphasises the safety aspect of managing traffic systems as well as the environment protection and sustainability issues.
- **Municipal and Regional Planning Strategies:** In this section, the role of TSM and strategic planning at the municipal and regional level is explained within the context of land use and environmental constraints. It also includes the role of public participation in transportation contemporary challenges.
- **Institutional Arrangement:** This section describes the role of the municipal-national interaction toward sustainable traffic systems management. It also highlights the role and duties of each stakeholder at the administrative, planning, design, operations, maintenance, and construction levels. It also highlights the role of law enforcement, public awareness, training, and education in providing sustainable traffic systems.
- **Intelligent Transportation Systems (ITS):** This module identifies the ITS architectures and components and explains its application as an integrated system within TSM process. Moreover, it describes the different ITS strategies for node and link management techniques.

It is to be stated that since the course was established, its contents and the teaching and learning activities have been under continuous revision, enhancement, and advancement processes.

5. Classroom Environment

The TSM course has been taught as an elective course to senior students on a bi-annual basis. Large numbers of students compete to register for the course, which has a ceiling capacity of 30 students due to its dominant practical nature. The recent development in the course delivery included more concentration on the teaching-learning interaction with an emphasis on team work. The course utilizes a major tool in training the students through real-life projects. The classroom environment mainly includes, but not limited to:

- **Classroom Lectures:** The main focus in of the lectures is to explain the theoretical aspect of each TSM module.
- **Case Studies:** The aim of this component is to supplement students with TSM strategies and examples that have been implemented locally, regionally, and internationally, and to enrich their practical knowledge of the different TSM solutions, along with its environmental, operational, societal, and socioeconomic constraints. Students also are requested to bring and present such cases, followed by an open discussion among the students.
- **Multimedia Laboratory and Interactive Learning:** This component is used to explain, simulate, and demonstrate real-life TSM strategies, and deliver a better understanding of the physical meaning of each

module explained in the classroom lectures.

6. TSM Course Delivery Methods and Tools

In order to meet the pre-defined learning outcomes and competences, the course is implementing some tools to support the TSM course learning process. These tools are:

6.1. Textbook

Unlike many other engineering courses there, is no well-known textbook that can be adopted to meet course objectives. Therefore, a book titled "Traffic Systems Management: Concepts and Applications on Palestinian Cities" was developed as a tool to assist municipal and other local engineers training, as well as to assist in teaching students the concepts and applications of TSM [9]. The book summarizes the TSM concepts, the international experience, and the local applications.

6.2. Multimedia Contents

In addition to the textbook contents, a multimedia courseware was developed to cover part of the TSM course contents in an interactive way, benefiting from the experience gained in developing a pilot multimedia courseware in transportation engineering [10-11]. This courseware was developed following a web-based template so it becomes accessible online. The courseware includes the following features:

- Texts and Images: This is a default and the main component of multimedia tools. Texts and images are used to explain a particular TSM concept, with a typical example from real-life implementation in the form of an image to demonstrate that concept.
- 2d and 3d Animation: Some animated videos were created to explain some of the TSM strategies while they are taking place and in progress.
- Video Contents: This includes a real-life recording of some TSM concepts while in progress.
- Audio Contents: This provides an audio comments and explanation of some of the TSM concepts.
- Interactive Menus and Hyperlinks: Similar to websites, the use of these menus and hyperlinks is developed to create an interactive environment for the user while using the courseware. It allows users to select a particular concept within the courseware structure, jump to the next topic, or visit an external website.
- TSM Analysis Tools: The courseware includes some applications that can be used to demonstrate and compare the effect of implementing different TSM solutions on traffic and environment, and provide different measures of effectiveness to help engineers in the decision-making process.

6.3. Interacting with Stakeholders

Due to the practical nature of this course, the interaction with stakeholders is one of the key elements in course design and delivery methods. Students are required to communicate with Palestinian local municipalities, ministries including the Ministry of Transport, and funding agencies, such as PECDAR, while planning and performing their assigned TSM projects. Senior students have been encouraged to adopt graduation projects involving TSM applications. Feedback from students, municipalities, and official agencies was considered to improve the course contents as well.

6.4. Development, Enhancement, and Feedback Strategies

The course contents, the teaching-learning approaches, and the intended learning objectives have been under development since the course was found. Some senior graduation projects were designed to improve the course, such as through the development of a multimedia courseware describing some of the course contents. Forward-integrated teaching strategies are adopted. These strategies include:

- Development of a more advanced version of the course as part of the offered M.Sc. program in Transportation and Road Engineering.
- Development of graduation projects involving TSM applications. This strategy has already been adopted and is found to be appealing especially to students who took the course.
- Improvement of the course multimedia contents. This strategy is met by allowing students to develop a multi-media version for part of the course contents.

7. TSM Course Evaluation Methods

Students are evaluated based on their exams, assignments, and projects results. These three evaluation tools are designed to meet the ABET accreditation requirements. While exams and assignments are taking the traditional format, the projects are designed differently. For instance, exams and assignments may include short-answers, definitions, multiple choice, schematic sketches, and problem solving questions. Projects are designed to highlight other components, such as teamwork, time management, and critical thinking.

The intended learning outcomes are reviewed by the end of each term in order to identify the level at which they are met. Figure 1 shows the percentage met for each ILO for 33 students who took the course during the Spring Semester of 2011/2012 academic year. As can be seen in the figure, all the ILOs were met, but at different the levels of satisfactions. This process is used to identify the learning outcomes that need further attention. For this group of students, it is clear that the fourth learning outcome has the least score when compared to the other learning outcomes. This process is used to further highlight the weakness, so proper actions and measurements can be implemented to improve the course.

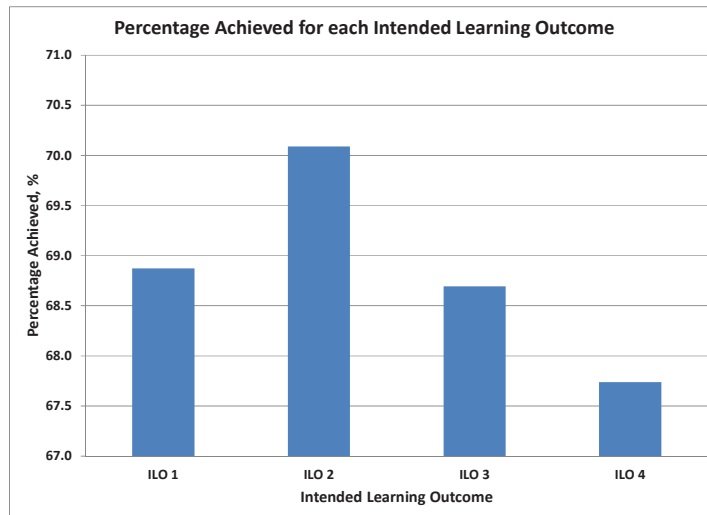


Fig. 1: Intended Learning Outcomes Achievement Level, Spring Semester of 2011/2012

8. Conclusions and Recommendations

This paper presents the development of an elective senior-level course in Traffic Systems Management (TSM), targeting students with interests in transportation and roadway engineering. While the course is mainly developed based on the local TSM experience for the Palestinian National Authority (PNA) in the West bank and Gaza Strip, it highlights the state-of-the-art international experiences and current practices of the developed countries. This course is intended to prepare transportation engineers, who are capable of designing and implementing different TSM strategies to facilitate the achievement of sustainable built environment. The course was recently upgraded to meet the Accreditation Board for Engineering and Technology (ABET) accreditation requirements as well, utilizing interactive learning-teaching approaches, such as in-class lectures, multimedia deployment, case studies, and open discussions. The TSM course also emphasizes the practical side through the interaction with stakeholders, such as the municipalities and local governments, and the relevant ministries and funding agencies. The course serves also as a platform for interaction with the municipalities, which are also considered as potential providers of training and even future career opportunities.

While this course is sufficient to prepare graduates at the local, regional, and international levels, the attained experience is recommended to be extended to provide training sessions to the engineers working at the municipalities, consulting firms, and relevant ministries. Furthermore, it is recommended use more demonstration tools and to improve the contents of the multimedia courseware. Moreover, designing final graduation projects involving TSM applications and interactions with the municipalities, or improving the multimedia contents is recommended.

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