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Identification of quality indexes in school bus transportation system

A. Sakellariou[a], K. M. Kotoula[b*], M. Morfoulaki[b], G. Mintsis[a]

[a]*Aristotle University of Thessaloniki (AUTH)*

[b]*Hellenic Institute of Transport/Centre for Research and Technology Hellas(HIT/CERTH)*

Abstract

School transportation is a special and important issue for society, as it refers and involves a very sensitive age group. Therefore, the appropriate design as well as the provision of maximum safety to students, are necessary actions need to be taken into account for the smooth functioning of a society. Within the last years, research in this field has gain interest as it aims to identify the special features affecting the school transportation system and determine the factors that substantially influence the level of the offered services. The current paper aims to investigate qualitative factors that affect a school transportation system's services executed by school buses. Firstly and in order to identify these factors, international literature research on school transportation has been undertaken revealing that the relating information is neither completed nor sufficiently documented. Secondly and in order to define the most important qualitative factors and assess the existing school transport system, a questionnaire survey is conducted to parents of private high school students in the area of Thessaloniki. Finally, the conclusions of the investigation are analyzed and factors that need improvement in the existing school transportation system are identified. In addition, a school transportation satisfaction index is estimated and by using linear regression analysis, the factors that influence it are determined. The definition of the satisfaction index permits the sector of the school transportation system to prioritize the necessary interventions to be implemented and shed light on the user satisfaction impact of these interventions.

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* Corresponding author. Tel.: +30-2310-498441; fax: +30-2310-498269. E-mail address: nilia@certh.gr

1. Introduction

School transportation is a special and important issue for society, as it refers to a very sensitive age group. Therefore, the appropriate design and the provision of maximum safety are necessary actions need to be taken into account while organizing such a system. School transportation includes all the modes of students' transfer to and from school units and school activities. Walking, biking, use of private cars, buses and taxis are all modes composing a school transportation system, while students, parents, relatives and friends, teachers, drivers and school bus attendants are the basic stakeholders (Morfoulaki et al, 2015). Each of them plays a crucial role in the whole procedure and is responsible for students' safety. Parents and teachers educate students from their early age about the rules ensuring a safe trip, while drivers and school bus attendants constantly remind and inform them about the appropriate behavior they should demonstrate throughout the whole trip.

School buses are on the top of the list when referring to safe modes of transfer, as these are designed and manufactured

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specifically for the protection of pupil passengers. Statistics suggest that a child travelling by car is seven times more likely to be involved in a road traffic accident than a child travelling by bus (European Commission Transport Road Safety, 2004). Similarly, statistics from USA, Canada and Australia confirm that school transportation by buses presents a high level of safety, just as in Europe. More specifically, the Australian College of Road Safety (ACRS), claims that bus travel is at least fourteen times safer than the use of private vehicle, while a research undertaken by the National Highway Traffic Safety Administration (NHTSA, 2014) in the USA, notes that when comparing the number of fatalities of children aged five to eighteen during the school transportation hours, school buses are 87 times safer than private cars. In Greece, the school bus transportation is divided into three major categories; private school bus transportation serving primary school students (door to door services), private school bus transportation serving high school students (where specific stops are pre determined according to the parents' needs), public school bus transportation serving primary and high school students (where specific stops are pre determined by school units in cooperation with the transport providers) (Morfoulaki et al, 2015). There are particular rules regulating and overseeing the system's appropriate function, such as maximum speed limits compliance, seat belts provision, attendant existence on the bus , mandatory annual roadworthiness controls, installation of signage on the front and the back of the bus, etc. (School Transport Safety Legislation in Greece, 2009). In contrast with the public school transportation system, the private school system seems to be more organized. For example, private school students are received and delivered from/to their residences (which is considered more safer), while for public school students specific stops are designated for this purpose (which may be located a quite long distance from students' residences). Moreover, all private elementary schools provide a school bus attendant responsible for pupils' safety inside the bus, a service which unfortunately is not provided to primary school students of public schools. (Morfoulaki et al, 2015)

Safety in school transportation can be determined by many different factors. The violation of traffic laws is a very common factor leading to an accident. According to a research took place in Athens, 2007, 147 infringements were identified within a month through 2.623 police controls (Chalkia et al, 2009). The 27,5% of the violations referred to the non use of seat belt. In a similar research in Athens, 2006, the violations included in a high rate (12,8%) speed violations. Generally, some of the safety key factors in school transportation are the driving behavior, the vehicle condition, the driving environment, the student's behavior while on the bus, as well as the use of technological equipment which can increase the safety levels.

Taking into account the above, the paper attempts to identify a number of qualitative factors that affect a school bus transportation system and its safety. Therefore, a questionnaire survey is conducted in parents of students attending private high schools in the area of Thessaloniki, Greece, in order the most important factors to be defined. Following, a school transportation satisfaction index is estimated and by using a linear regression analysis the factors that influence it are determined. The definition of the satisfaction index permits the field of the school transportation system to prioritize the necessary interventions need to be implemented and sheds light on the user satisfaction impact of these interventions.

1.1 Qualitative factors affecting a Public Transport System

Today, European countries do not follow a common school bus transportation law and each country sets its own regulations. Nevertheless, the school bus transportation system subjects to the most stringent regulations when comparing to other transportation systems. In the current paper, due to inadequate research and literature that exists on quality and operational factors evaluating a school bus transportation system, a literature review in public transport systems is preceded, based on the assumption that the school transportation can be considered as a public transportation system. In order to evaluate the level of service (LoS) of a public transport system, the Transit Capacity and Quality of Service Manual (TCRP,2013) is used according to which, there are two aspects for evaluating a public transport system. The first examines the option of using a public transport system (assessing availability) and the second one evaluates the system against others that are available, in terms of comfort and trip easiness (evaluation of the provided quality).

The availability of a transport service, is evaluated by a number of factors that affect it. An attractive public transport system provides stops close to passengers' points of origin and destination, dense pedestrian crossings, and functional

pavements along the routes. Time availability is also important for passengers. Public transport systems providing frequent services (minimization of waiting time) are more attractive than those providing more rare services. Information availability is another factor that seems to have an important impact in the selection of a transport service. Passengers need to know how to use a public transport system, how to access it, what payment procedure they need to follow and other useful information about the system such as last minute changes in route scheduling etc. Finally, the capacity availability is a factor highly considered by passengers. Insufficient capacity in a vehicle may affect the availability of a public transport service. A full bus arriving at a stop, will not be able to serve all passengers waiting there.

Regarding the evaluation of the provided quality, reliability is one of the most important factors passengers take into account, as it affects the time a passenger waits at a stop, the accuracy of arrival time at destination and generally the total travel time. Reliability is influenced by a number of factors, some of which depend on the transport providers' facilities (vehicles and staff availability, schedule compliance), while some are not (traffic conditions, road construction and maintenance services resulting in travel time changes). Another equally important factor is safety and security. Safety refers to the possibility someone could be injured during the trip (e.g. slips and falls) and security refers to the likelihood of someone becoming a victim of a crime during the trip. A secure bus stop is placed in a safe area, is enlightened, has benches, shelters, information boards and other useful facilities. Apart from the stops, vehicles have a significant role too. Passengers want a comfortable trip so they need not too crowded vehicles, with seats that they could use the time for travel productively (reading etc.), suitable climate control inside the vehicle, etc. Another significant factor of evaluation is the cost of the service. A proper public transport system should compete the direct cost of the private vehicle and not be much more expensive. The last factor that someone evaluates in a public transport system, is the relationship between staff and passengers. A transport system which staff is friendly and helpful, is more attractive than other.

1.2 Qualitative factors affecting a School Bus Transport System

Regarding the qualitative factors affecting the school bus transportation, the existing literature is rather limited. However, the existence of appropriate sidewalks along the route from the residence to the school bus seems to play a crucial role in students' safety, while poor surface pavements, routes interrupted by trees, light poles or other fixed obstacles greatly reduce the level of the services provided (Evers et al, 2014). According to Morfoulaki et al (2013), the distance from the residence to the bus stop, the road network environment, the absence of sidewalks, the absence of attendants within the school buses and the absence of appropriate seatbelts are factors that highly affect the levels of services in such systems. Moreover, new technology applications (active information boards at the stops informing students about the arriving time of the bus, trips rerouting due to emergencies, systems detecting dangerous drivers' behaviors, etc) are on the top of the list regarding the increase of safety levels. Additionally, Bass et al (2012) support that for students reaching the school bus by private vehicles, a parking near the bus stop is deemed as necessary. The appropriate location of the bus stop, (elimination of the need for road crossing by students), slowing down traffic when a bus reaches a stop are some actions that can enhance a school bus transportation system (Kursius et al. 2002). Such actions are also mentioned in BUSSTAC research (New Zealand, 2012). Another crucial factor for students' safety is the proper design of a bus as well as its maintenance (Transportation Research Board, 2002). Table 1 summarizes recent findings regarding the qualitative factors affecting a school bus transportation system

2. The research

For the identification of the factors influencing the LoS of a school bus transportation system, a questionnaire survey was conducted online via Google Forms and massively sent in lists created by the research team for this purpose. The questionnaire, was based on the qualitative factors being used for the evaluation of a public transport system as many similarities are identified between the two systems as mentioned above. The target group included parents of private high school students in the area of Thessaloniki, Greece daily transferred by school buses. The reason for selecting private high schools is that the school transportation system is more organized compared with the one of public schools and usually conforms to the international regulations. Moreover, a high school student usually walks from his/her residence to the bus station and therefore additional factors can be examined regarding this phase of the trip.

The survey was conducted during the school period, lasted 15 days and in total 48 questionnaires were collected. The sample cannot be considered as a satisfactory one. It is worth mentioning that this was an extremely focused research which as retrospectively proved the target group was not so willing to participate in. The questionnaire consisted of five parts; the first one included the respondents' demographic characteristics, while the second one included the students' characteristics. The third part referred to the evaluation of eleven qualitative factors (significance and satisfaction) regarding the existing school bus transportation system. The qualitative factors referred to all trip's phases; walking from the residence to the bus stop; waiting at the bus stop; travelling by bus. At the fourth part of the questionnaire, additional potential services were suggested and respondents were invited to assess their significance. The last part included an assessment of the parents' overall satisfaction regarding the existing school bus transportation system.

1.3 Descriptive analysis

According to the questionnaire analysis, the sample is consisted of men and woman at the same proportion. Most of the respondents are 40-50 years old (45,83%) and university graduates. The majority of them possess driver license and always makes use of the seatbelt. Regarding the students' profile, 60,42% are girls aged 15 (43,75%). For the majority of them, the distance from their residence to the bus stop is between 50-150 meters and they usually walk there on their own. Regarding the bus stations, 31,25% of the respondents claim that safety is not provided while students wait for the school bus, while the other 35,42% totally disagrees.

The research reveals that all the examined qualitative factors are considered significant regarding the students' safety (scores range from 6.40 to 9.31). The respective scores identifying the respondents' satisfaction range from 4.9 to 7.31, for 11 factors. For the rest twelve factors satisfaction scoring is not required as the specific factors are not typical of the examined school transportation system.

Table 1 Significance and Satisfaction of qualitative factors affecting a school transportation system

Qualitative Factors	Significance	Satisfaction
Time/ Walking distance from the residence to the school bus stop	7.44	6.92
Road network and traffic conditions	8.15	4.94
Existence of traffic lights on intersections along the route from the residence to the school bus stop	8.29	5.17
Suitably designed sidewalks along the route from the residence to the school bus stop	8.48	4.90
Existence of barriers and traffic restrictions along the route from the residence to the school bus stop	7.79	5.85
Waiting time at the school bus stop	8.02	7.06
Travel time within the school bus	8.27	6.38
Travel costs	8.58	5.52
Seats' comfort in the school bus	7.38	6.46
Cleanness of the school bus	8.44	7.31
Maintenance of the school bus	9.31	6.63
Existence of Variable Message Signs on school bus stops	7.17	-
Suitably designed and located school bus stops	8.38	-
Existence of sheds in school bus stops	8.83	-
Availability of seats in school bus stops	6.40	-
Existence of attendants within the school bus	7.44	-
Existence of three-point seatbelts on school buses	9.10	-
Systematic control of seat belt use	8.77	-
Existence of systems controling drivers' behavior	9.17	-
School bus arrival time information on school bus stops	8.67	-
Provision of real time information regarding the school route	7.50	-
Provision of information regarding various incidents during the trip	8.69	-
Provision of information regarding route changes in case of emergencies	8.67	-

Overall, the total satisfaction of the existing school transportation system scores 6.62 out of 10, leading to the conclusion that more actions must be promoted in order the safety levels of the school transportation system to be increased.

1.4 Quadrant analysis

Following the descriptive analysis, a quadrant analysis is also conducted in order the levels of significance and satisfaction of each qualitative factor to be identified (Figure 1). In case some factors score an unacceptable level of satisfaction, further actions should be proposed in order to improve the school transportation system.

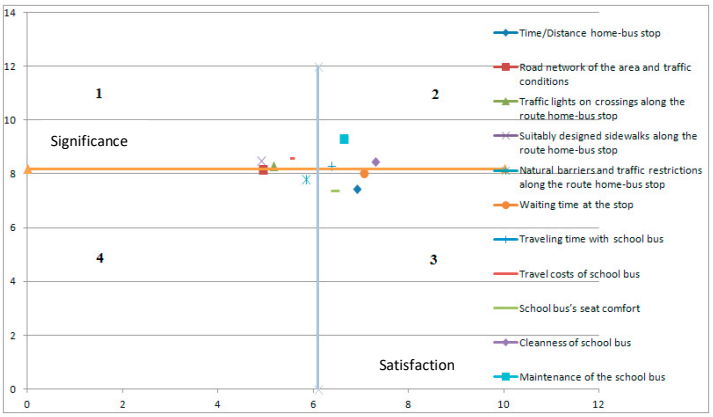

Figure 1 Quadrant analysis of qualitative factors defining the school transportation system

According to Figure 1, significant factors that are not satisfied are concentrated in the first quadrant (suitability of sidewalks along the students' trip from the residence to the school bus, existence of traffic lights on signalized intersections etc) , while significant factors highly satisfied are concentrated in the second quadrant (maintenance of school bus, time spend on the bus, etc). In the third quadrant there is an excessive satisfaction of factors that are less important for the respondents (waiting time at the bus station, time/distance from home to the bus station, etc). No further improvement of these factors is demanded, as they are less important regarding overall satisfaction of the existing school transportation system. The fourth quadrant includes the factors that are not so significant according to the survey's respondents and the perceived level of service does not satisfy them. However, a later improvement could be attempted in order to examine whether the improvement would have positive effects in the significance of the factor.

1.5 The LoS model.

A model has been developed for the estimation of the statistically significant coefficients of the perceived LoS for the current school bus transportation system based on the survey data. Initially, correlation matrixes were calculated in order to identify the possible relationships between the different variables. A significant number of correlations was tested leading to the conclusion that most variables are highly correlated, and cannot be concurrently input to the model. After many trials, the factors providing the best results in the model were found to be "time/distance from residence to the bus stop" and "information about changes of bus stops or routes in case of emergency incidents occur". The correlation between these two variables, which is made by the Correlation Analysis Bivariate method and specifically the Pearson correlation index is presented in Table 2.

Table 2 Pearson correlation index.

		Time/distance house- bus stop (Satisfaction)	Information about changes of bus stops or routes in case of emergency incidents
Time/distance house - bus stop (Satisfaction)	Pearson correlation	1	,091
	Sig.(2-tailed)		,539
	N	48	48
Information about changes of bus stops or routes in case of emergency incidents	Pearson correlation	,091	1
	Sig.(2-tailed)	,539	
	N	48	48

Regarding the linear regression model, progressive procedure (forward) of the SPSS program has been used. The results of the analysis are depicted in Tables 3a, 3b and 3c. In Table 3a the Adjusted R square is 0,964 meaning that the selected factors describe the 96,4% of the information of dependent variable. Moreover, Table 2b shows that the prediction of the dependent variable from the independents is a statistically significant. Last but not least, Table 3c indicates that the coefficients of the selected variables are acceptable, because in both cases confidence intervals do not include zero.

Table 3a Composition of linear regression model (a)

Model Summary				
Model	R	R square	Adjusted R square	Std. Error of the Estimate
1	,983[a]	,966	,964	1,305

Table 3b Composition of linear regression model (b)

ANOVA						
Model		Sum of squares	df	Mean Square	F	Sig.
1	Regression	2211,615	2	1105,807	648,938	,000[a]
	Residual	78,385	46			
	Total	2290,000[b]	48	1,704		

Table 3c Composition of linear regression model (c)

Coefficients[a],[b]

Model		Unstandardized Coefficients		Standardized Coefficients			95% Confidence Interval for B	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
1	Time/distance home - bus stop(Satisfaction)	,480	,059	,520	8,068	,000	,360	,600
	Information about changes of bus stops or routes in case of emergency incidents	,377	,050	,487	7,562	,000	,276	,477

The final regression model is presented in Table 2c. The distribution of the noise of the data is normal according to Figure 2, which is another indicator of the validity of the model.

$$Y = 0{,}480 \times (time\backslash distance\ home - bus\ stop\ (satisfaction)) + 0{,}377 \times (information\ about\ changes\ of\ bus\ stops\ or\ routes\ in\ case\ of\ emergency\ incidents)$$

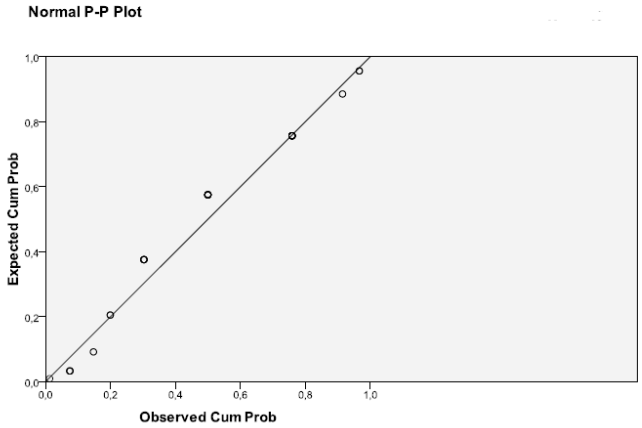

Figure 2 Distribution of residues of the linear regression model

3. Conclusion

The current study investigates the LoS of the school bus transportation system in private high schools of Thessaloniki, Greece. The survey conducted, revealed useful information about the significance and satisfaction of eleven qualitative factors affecting the safety levels of the school bus transportation system according to the parents' requirements and needs. Almost all factors were evaluated as significant, with the only exception of the "seats' availability at a bus stop". Although, all factors are considered highly significant, the perceived satisfaction of the current school bus transportation system ranges in a rather low level. As a result the school bus transportation service as provided today, needs immediate corrective innervations. The quadrant analysis conducted, revealed that the factors need immediate improvement are the existence of traffic lights on signalized intersections, appropriate designed sidewalks along the students' route from their residence to the bus stop and reduced travel costs. These factors are the most significant ones but the level of satisfaction is low. As the linear regression model revealed, two factors influencing highly the

level of service is the satisfaction of the time/distance from the students' residence to the bus stop as well as the rerouting information at bus stops in case of emergency incidents. These two factors according to the research should always be kept in high satisfaction levels, as they determine the level of service.

As a next step of this study, an expansion of the existing collected data is recommended. A wider survey is considered as crucial, in order the results to be more reliable. In this case, a different model may occur, using more factors leading thereby to more reliable results. Finally, further research is required worldwide regarding the crucial qualitative factors that determine a successful school transportation system.

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