The Greening of Student Pick-Ups at School Dismissal

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Strategies for the Greening of Student Pick-Ups at School Dismissal

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Abstract. Excessive queuing by parent vehicles picking-up their elementary-aged school children is becoming problematic in terms of both safe traffic operations on adjacent streets, as well as in increasing the individual school's carbon footprint.

Adjacent street systems typically do not provide enough capacity to handle the stacking of parent vehicles in existing through lanes. This situation presents safety issues to existing traffic on the street system unrelated to the school traffic as well as to school related traffic. Where insufficient on-site stacking is provided on the school property, vehicles spill out onto the through lanes of the surrounding street system. Safety issues become apparent when students walk through parked cars in order to cross the street. Rear-end crashes also increase due to vehicles being stopped in through lanes of traffic.

Emissions from vehicles can become excessive when parents queue to pick up their students. Volatile Organic Compound (VOC) and Carbon Monoxide (CO) emissions both increase during stop-and-go traffic or when a vehicle is idling[1]. Thus, vehicles queued to pick-up their student produce more VOC and CO than vehicles at free-flow speed.

This paper offers strategies and state-of-the-practice methodologies to plan for the maximum expected vehicle queue during school dismissal at new or planned elementary schools. A rule-of-thumb for estimating the maximum queue length of parent vehicles at planned elementary schools will be presented. Also, recommendations and strategies will be given in order to reduce maximum queue lengths and the carbon footprints of existing elementary schools.

INTRODUCTION

Over the last ten years in and around the Houston, Texas, metropolitan area parents of elementary-aged students are increasingly relying on their personal vehicle to drop-off and pick-up their students to/from school. Dependence on alternative modes of transportation, whether it is bus ridership, walking, biking, or even carpools is dwindling. Several variables, including demographics, convenience and a presumed danger of letting students walk and bike to school all contribute to the over-reliance of personal vehicles to transport elementary-aged schoolchildren to and from school.

During a typical morning drop-off event at an elementary school, the trips to the school are dispersed more normally across a broader time range than the peaking characteristics of an afternoon pick-up event and the morning trips do not typically present any traffic or safety operation issues. Onsite (or offsite) queuing during a typical morning drop-off event is negligible to minimal. However, the afternoon pick-up event attracts parents trying to "get in line first" in order to leave the queue as soon as possible upon the release of the students from school. Dismissal queuing is what causes traffic congestion both onsite in the school parking lot/queuing loop and offsite in the through lanes of adjacent roadways. Vehicle exhaust emissions, such as VOC and CO increase when vehicles idle or are in stop-and-go conditions [1].

The topic of parent pick-up zones has not received considerable attention from the engineering and planning community until the recent years. Parent pick-up zones have long been overlooked in the initial elementary school site design process. However, even just minor improvements and strategies that address both sides of the following equation can provide significant results.

[Improve roadway safety and operations] + [Improve air quality and reduce vehicle emissions] =
A safer, "greener", student pick-up

IMPROVE ROADWAY SAFETY AND OPERATIONS

The root causes of unsafe walking and biking modes of transportation for elementary-aged schoolchildren are pedestrian/vehicular/bus conflicts and the queuing of vehicles in through lanes of adjacent roadways. A higher number of conflict points between pedestrians and vehicles/buses obviously increases the likelihood of accidents between the two. Many times schoolchildren attempt to cross streets between parked or idling vehicles, or even load into the vehicles while the vehicle is queued in a though lane of travel. **Figure 1** below shows this exact scenario of a long line of queued vehicles in a through lane of an adjacent street while a group of pedestrians are waiting to cross the street between vehicles. Students can also be seen loading into the passenger side of multiple vehicles while the vehicles are parked in a through lane of travel.

Figure 1 – Pedestrian and Vehicular Conflict Points

The primary tool to reduce the number of conflict points between elementary school pedestrians, vehicles and buses is to segregate bus pick-up, vehicle pick-up and pedestrian egress from different exit points of the school. Ideally, a bus pick-up loop is on one side of the building while the parent pick-up loop is on the other side. The pedestrians are then released from a third location in order to minimize interaction between all three modes. To further improve on the bus/vehicle/pedestrian segregation, the following strategies have been observed to work well and each comes with its own advantages.

- Delay the release of pedestrians until all private vehicle riders and bus riders have been loaded. This strategy ensures the least amount of bus/vehicle/pedestrian conflicts.
- Delay the release of private vehicle riders and bus riders until all pedestrians have been released. This strategy reduces but does not eliminate conflict points as some walkers/bikers will linger around the campus or walk slowly through the surrounding street network. However, this strategy promotes the pedestrian mode since these students will be released earlier than the private vehicle and bus riders.

In order to develop a model to predict how much onsite storage should be constructed for parent pick-up vehicles, data from 55 elementary schools around the Houston, Texas, metropolitan area has been collected and is shown in **Table 1** and continued on the next two pages. The collected data includes primarily the total enrollment of the elementary school (in number of students) as well as the maximum observed queue length (in number of vehicles). The maximum queue length at each elementary school can then be expressed as a percentage relating the maximum queue length to the total enrollment of the school.

Table 1: Elementary School PM Pick-Up Observations in Greater Houston, Texas

	Observation Date	Total Enrollment (Students)	Maximum Queue (Vehicles)	Percentage of Enrollment for Maximum Queue
Katy Independent School District (ISD)				
Franz Elementary	2/7/2007	1,231	83	6.7%
Schmalz Elementary	2/5/2007	1,185	69	5.8%
Griffin Elementary	2/6/2007	930	60	6.5%
Woodcreek Elementary	12/7/2007	687	55	8.0%
Cy-Fair ISD				
Andre Elementary	12/7/2006	1,553	85	5.5%
Duryea Elementary	12/7/2006	1,150	58	5.0%
Sheridan Elementary	12/7/2006	1,321	75	5.7%
Walker Elementary	12/7/2006	1,324	69	5.2%
Keith Elementary	12/4/2007	1,036	61	5.9%
Ault Elementary	12/6/2007	1,100	68	6.2%
Cy-Lake Elementary	8/28/2008	1,483	78	5.3%

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	Observation Date	Total Enrollment (Students)	Maximum Queue (Vehicles)	Percentage of Enrollment for Maximum Queue
Warner Elementary	12/8/2008	1,015	58	5.7%
Hemminway Elementary	1/13/2008	982	50	5.1%
Copeland Elementary	3/5/2009	1,330	79	5.9%
Postma Elementary	3/5/2009	1,057	77	7.3%
Birkes Elementary	3/6/2009	1,335	71	5.3%
Spring ISD				
Winship Elementary	12/12/2006	845	43	5.1%
Salyers Elementary	12/12/2006	715	53	7.4%
Cooper Elementary	11/28/2007	1,199	80	6.7%
Meyer Elementary	11/28/2007	1,261	95	7.5%
Ponderosa Elementary	12/13/2007	742	55	7.4%
Reynolds Elementary	11/28/2007	813	59	7.3%
Magnolia ISD				
Bear Brach Elementary	11/1/2006	841	58	6.9%
Ellisor Elementary	11/1/2006	785	48	6.1%
Smith Elementary	11/1/2006	750	44	5.9%
Magnolia Elementary	1/4/2007	560	50	8.9%
Aldine ISD				
Dunn Elementary	3/19/2007	1,264	84	6.6%
Magrill Elementary	3/19/2007	1,286	82	6.4%
Vine EC/PK Center	3/1/2007	750	41	5.5%
deSantiago EC/PK Center	3/7/2007	709	68	9.6%
Hinojosa EC/PK Center	11/26/2007	671	65	9.7%
Keeble EC/PK	11/26/2007	850	58	6.8%
Macgrill Elementary	5/13/2008	1,502	100	6.7%
Humble ISD				
Summerwood Elementary (1-5)	1/25/2007	594	45	7.6%
Summerwood Elementary (K)	2/2/2007	146	31	21.2%
Eagle Spring Elementary (K)	3/4/2009	159	28	17.6%
Eagle Spring Elementary (1-5)	3/4/2009	869	61	7.0%
Tomball ISD				
Willow Creek Elementary (K-4)	4/11/2007	951	56	5.9%

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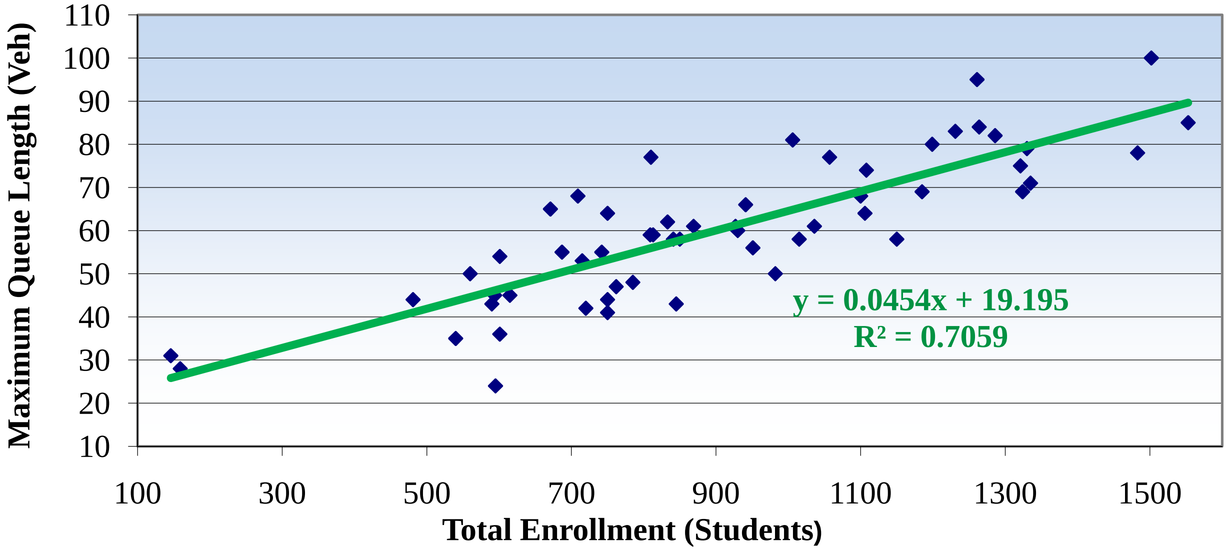
	Observation Date	**Total Enrollment (Students)**	**Maximum Queue (Vehicles)**	**Percentage of Enrollment for Maximum Queue**
Lakewood Elementary (K-4)	4/12/2007	833	62	7.4%
Tomball ES (PreK-4)	3/13/2008	615	45	7.3%
Lamar CISD				
Frost Elementary	9/6/2007	1,108	74	6.7%
Meyer Elementary	4/30/2008	762	47	6.2%
Needville ISD				
Needville Elementary	12/3/2007	1,006	81	8.1%
Texas City ISD				
Kohfeldt Elementary	3/28/2008	481	44	9.1%
Fort Bend ISD				
Scanlan Oaks Elementary	5/9/2007	1,106	64	5.8%
Sienna Crossing Elementary	5/8/2007	941	66	7.0%
Oakland Elementary	5/7/2008	809	59	7.3%
Burton Elementary	5/13/2008	927	61	6.6%
Holley Elementary	9/14/2009	750	64	8.5%
Jordan Elementary	9/15/2009	810	77	9.5%
Spring Branch ISD				
Westwood Elementary	5/12/2008	595	24	4.0%
Wilchester Elementary	5/28/2009	601	36	6.0%
Housman Elementary	8/31/2009	540	35	6.5%
Edgewood Elementary	9/1/2009	720	42	5.8%
Valley Oaks Elementary	9/2/2009	590	43	7.3%

The data gathered from observations of the 55 elementary schools across the greater Houston, Texas, region over the past four years can be plotted and fitted with a best-fit linear regression trend line. **Figure 2** displays the plotted data along with the linear regression results.

Figure 2 - Onsite Elementary School Stacking Design Length



From the linear regression trendline above, an R^2 value of 0.71 signifies that the maximum queue length is roughly 71% dependent on the total enrollment of the elementary school. Other factors that affect the maximum queue length on any given day are factors such as the weather conditions, demographics, day of the week, etc. But for the purposes of this statistical model, a good "rule-of-thumb" for estimating the maximum queue length while in the school site planning process can be developed. The formulaic relationship from the best-fit linear regression trend line can be rounded and expressed as follows:

$$Q = 0.05(S) + 19$$

where:

Q = Maximum Queue Length (veh)
S = Total Enrollment (students)

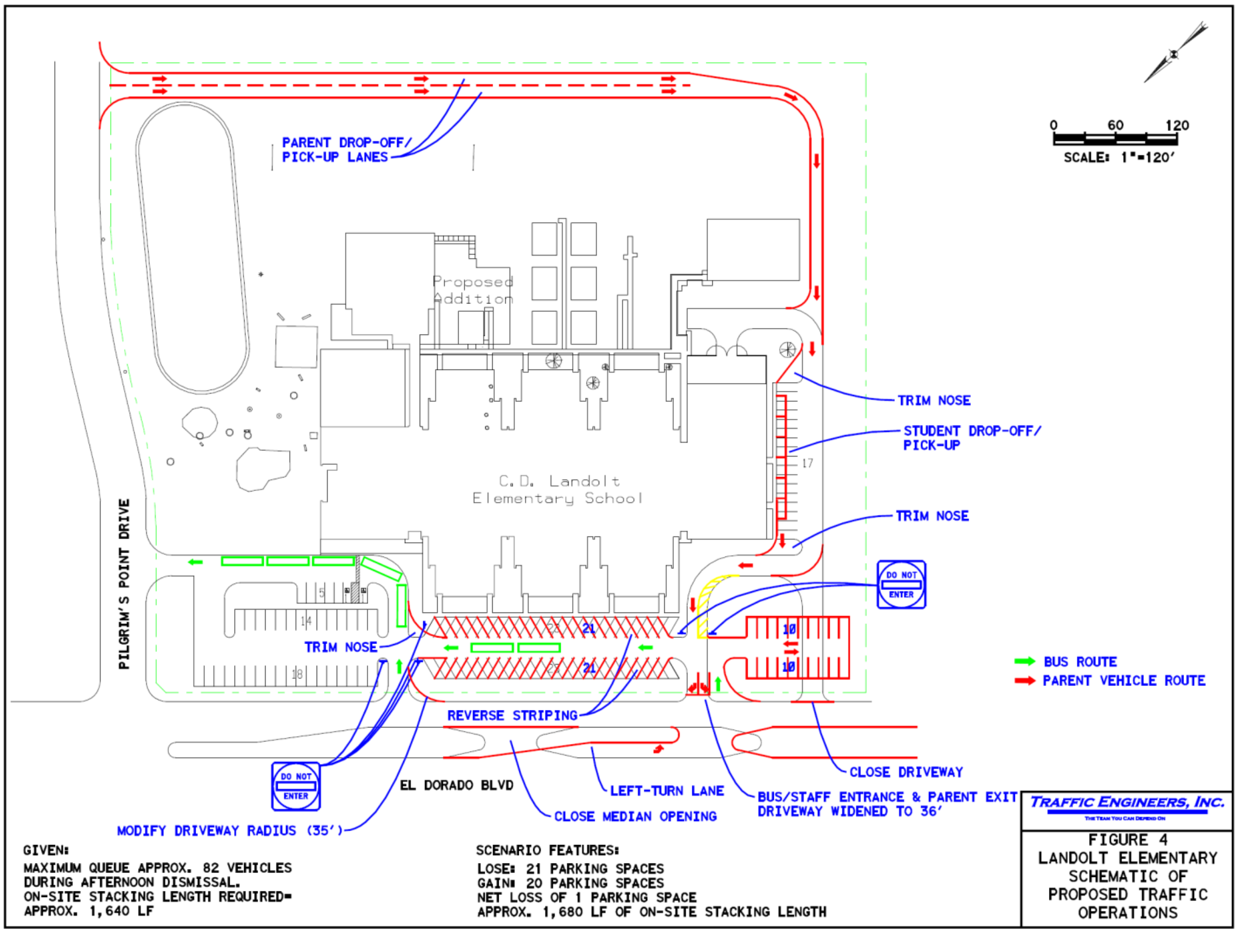
To put it even simpler and in a more "rule-of-thumb" format, when the best-fit linear regression line that is forced to pass through the origin of (0,0) is added to Figure 2 (and thus removing the y-axis intercept component), the formulaic expression presented above gets reduced to:

$$\boldsymbol{Q = 0.06(S)}$$

Or to put it in "rule-of-thumb" terms, the expected onsite maximum queue length, in vehicles, is approximately six percent of the total enrollment, in students. This "rule-of-thumb" could play a vital role in the school site planning process by providing an initial tool for estimating the amount of onsite stacking space required. Providing sufficient onsite stacking space will ensure the maximum queue of vehicles never overflows onto through lanes of adjacent roadways.

For existing elementary schools that are experiencing vehicle queuing onto the through lanes of adjacent roadways, there are retrofit options that could mitigate the existing roadway operations. Onsite stacking lanes can be designed and constructed to store the typical maximum queue length onsite and off of the through lanes of adjacent roadways. A recent case-study was able to be realized when Landolt Elementary School, of Clear Creek ISD in Harris County, Texas, constructed an onsite stacking roadway that provided two lanes of stacking up to the covered pick-up area as shown at the top of the figure in red in **Figure 3** below.

Figure 3 – Proposed Traffic Operations at Landolt ES, Harris County, Texas



Landolt Elementary School had been experiencing a maximum queue of approximately 82 vehicles during a typical afternoon dismissal. The amount of existing onsite stacking space held a maximum of eight vehicles; thus congestion on the surrounding roadway network was extensive for approximately 30 minutes every weekday. Queuing in the through lanes of El Dorado Boulevard, a major arterial of Harris County, Texas, occurred daily. Since the construction of the onsite stacking lanes, the maximum queue of vehicles on these lanes has not spilled onto the through lanes of any adjacent street. Better segregation between buses and private vehicles was also achieved with the improvements. **Figure 4** shows the "before" conditions at the school, while **Figure 5** shows the "after" conditions.

Figure 4 – Landolt Elementary School "Before" Onsite Stacking Lanes

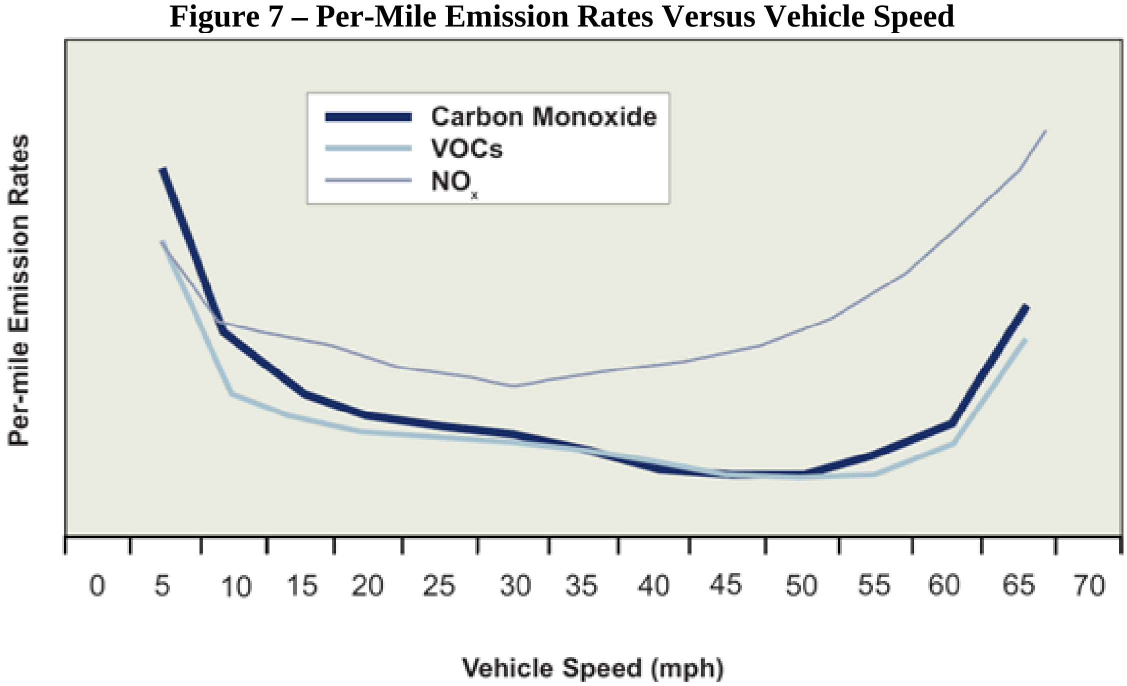
Figure 5 – Landolt Elementary School "After" Onsite Stacking Lanes

REDUCE VEHICLE EMISSIONS AND INCREASE AIR QUALITY

School children are often corralled and stationed outside during the afternoon dismissal from elementary schools in and around the Houston, Texas metropolitan area. These school children are breathing in vehicle emissions while private vehicles are queued onsite to pick them up. Rates of harmful vehicle emissions such as VOC and CO increase during vehicle idling and stop-and-go conditions. **Figure 6** shows a typical case of students stationed and corralled outside immediately next to an excessive onsite queue of idling vehicles. **Figure 7** displays the correlation between per-mile emission rates versus vehicle speed [1].

Figure 6 – Students Stationed Adjacent to Queued Vehicles

Figure 7 – Per-Mile Emission Rates Versus Vehicle Speed



The State of Texas alone has approximately 5,050 (and rising) elementary schools. The following assumptions, based on observed data where applicable) are utilized in order to calculate the approximate amount of CO_2 emissions produced annually by Texas elementary schools:

- 180 school days per year
- 60 vehicles in a typical afternoon dismissal queue
- 25 minute average idling time while waiting for students to be dismissed
- 0.0156 gallons of gasoline consumed per hour by a vehicle while idling
- 19.564 lb of CO_2 per gallon of gasoline

Multiplication of the applicable numbers above yields an approximate value of between 20,000 and 35,000 metric tons of CO_2 produced annually by elementary schools in the State of Texas.

The responsibility of reducing this amount of CO_2 production is spread equally over three primary factions:

- **School districts and individual schools –** Primary responsibility is to increase the efficiency of the student loading process. Best observed practices include:
  - Staggering the dismissal of students by grade level
  - Installing a two-stage loading process that utilizes hang-tags or placards placed in vehicle windshields to identity students to be picked-up. One school staff member relays the students' names to another staff member further up the queue line to arrange students in order of pick-up vehicle. Students then get loaded in up to six vehicles at a time, with a wave of six vehicles arriving after the preceding six vehicles.
- **Governmental agencies –** Primary responsibility is to educate the public to make them aware of the benefits of ride-sharing programs and safe-routes-to-school (SRTS) efforts that promote walking and biking to school. Best observed practices include:
  - Instilling green thinking into the community with printed materials and media encouraging the public to walk and bike to school.
  - Suggesting to parent drivers through print, radio and television media to turn off vehicle engines while queued up in school driveways.
  - Utilizing the internet like officials with Marin County, California, who used federal grant money to develop a "School Pool" ride-matching website that pairs up students who live along similar routes to school. Parents can then coordinate and commence carpooling.
- **Elementary students and their parents –** Primary responsibility are efforts to reduce the number of pick-up vehicles during elementary school dismissal. Best observed practices include:
  - Forming ride-sharing or multi-family carpools in which up to three or four families rotate weeks of picking-up all the students in the carpool.
  - Utilizing "express lanes" at schools that provide a shorter queue exclusively for families involved in ride-sharing or carpools.

A simple goal of either reducing the amount of vehicles that participate in the afternoon dismissal at a given elementary school (a function of governmental agency and parent responsibilities), or in reducing the time duration of the student loading process into the vehicles (a function of school district responsibilities) could drastically reduce the amount of CO_2 emissions produced annually by elementary schools in the State of Texas.

Reducing either the number of pick-up vehicles by 50%, or reducing the time duration of the loading process by 50% could lead to an approximate savings of 10,000 to 17,500 metric tons of CO_2 emissions per year just in the State of Texas alone. For a frame of reference, **Figure 8** displays what *just one* metric ton of CO_2 emissions looks like (the amount of CO_2 emissions that could fit within the white cube in the photo is one metric ton). [2]

Figure 8 – Representation of One Metric Ton of CO_2 Emissions

EMERGING TECHNOLOGIES

Perhaps the best practice observed in terms of both student loading efficiency, safety and mitigation of vehicle idling while waiting in queue is the emerging use of automatic bar-code reading technology. Brookshire Elementary School, of the Orange County Public School System in Winter Park, Florida, has recently seen drastic results with the utilization of a bar-code reader system.

The entrance of the school driveway is equipped with a bar-code reader that reads a bar-code decal on each pick-up vehicle entering the driveway. Students to be picked-up are staged inside the school in a classroom equipped with a large-screen television monitor that arranges students' pictures in succession according to successful scans of the bar-code decals at the school driveway entrance. This automates the two-stage loading process while keeping students away from breathing any emissions of vehicles in the queue. Safety is also increased due to students being staged inside the school building. Unsuccessful bar-code scans or vehicles that do not have a bar-code at all are asked to park and come to the school office to provide identification before being allowed to pick-up a student.

Within a couple of weeks of using the bar-code reading system, Brookshire Elementary School was able to see a reduction of near 50% in the overall time duration from the beginning of student loading to the end of the loading process.

Photographs of the reader, bar-code decal and television monitor in the classroom are shown in **Figure 9** below.

Figure 9 – Bar-Code Reader Emerging Technology in Elementary School Student Pick-Up

CONCLUSIONS

- Improving the student pick-up process for elementary schools has a significant safety and environmental benefit for the respective school and for the community.
- Planning in the elementary school site design phase is best, but there are retrofit options.
- Statistical models can be developed to design sufficient onsite queue storage required for elementary schools to contain the maximum expected queue length of vehicles.
- An initial "rule-of-thumb" has been developed based on data collected from over 50 elementary schools in Houston, Texas. This "rule-of-thumb" states that the expected maximum queue length (in vehicles) that will queue during an afternoon dismissal of an elementary school is approximately six percent of the total enrollment of the school (in students).
- Emerging technologies, such as bar-code reader systems, have shown to have positive results for improving the elementary student loading process.
- Improving traffic operations for elementary schools requires collaborative efforts between primarily governmental agencies, school districts, students and their parents.

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SOURCES

[1] Vehicle Emissions Pamphlet: http://esa21.kennesaw.edu/activities/smog-cars/doe-veh-pollutants.pdf, Accessed April 24, 2010.
[2] Cohasset High School, Cohasset, Massuchusetts, Dave Ames Science Class. Photo accessed from http://www.energyrace.com/commentary/what_does_a_ton_of_co2_look_like/

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