Teacher's Guide

- The main purpose of this lesson is to increase the visual awareness of the danger of the selfish drivers and their negative influence on the smooth flow of traffic, especially in the cities, as well as possibility of causing traffic accidents.

- The overall educational objectives can be summarized as follows:

  1) Providing a practical application of an important branch of mathematics, namely Game Theory.
  2) Educating students the importance of scientific research, especially in subjects that concern their countries.
  3) Training students on methods of counting and finding all cases in a given problem.
  4) Introducing the concept of Nash Equilibrium in a simplified manner.
  5) Introducing the concept of Braess's Paradox in a simplified manner.

- In this lesson we will introduce the concept of Nash equilibrium, which states that the road network is in equilibrium when each driver concludes that there is no benefit to him personally can result from changing his path as moving to any other path will not reduce the time necessary to reach his goal.

- We will explain also the concept of Braess's Paradox (the main focus of this lesson), which could be clarified as follows: at first glance, most of us may think that adding an additional path to a road network will certainly lead to a reduction in the congestion in this road network. We will show through specific examples that what might happen is quite the opposite!! In some cases, and assuming that all the drivers in the road network are selfish, this may increase the time required to get from one point to another at the status of equilibrium.

- I was keen not to include examples that include difficult equations. What a student needs as a prerequisite for understanding the content is to know how to solve two linear equations in two variables by substitution (or omission). The rest is simple calculation. In fact, I can say for sure that any student in the intermediate school can follow up this lesson easily.

- The video consists of seven video sections. Each section is followed by a activity. I would recommend dividing the students in the class into groups to carry out these activities and to leave some time for public discussion in the class.

- The main activities can be summarized as follows:

Activity I (2 minutes): Students shall try to answer the main question: Will closing the road **BC** increase or decrease the time required for all cars to cross from **A** to **D**?

Students will also explain their answers based on calculations which they should provide to support their conclusions.

Activity II (3 minutes): Students shall try to answer the following questions about Examples I & II:

- What are the possible routes to get from **A** to **D**?
- At any point(s) do the drivers have option to change their minds and choose a new route?
- At which point(s) become the route mandatory?
- When is the network at Nash equilibrium? What is the time required for each care to get from **A** to **D** in this case?

Activity III (4 minutes): Students shall try to find all possible distributions of the four cars on the various tracks before and after the addition of **BC,** and the total time required for the four cars in each case, and to note when we have the best possible total time.

Activity IV (4 minutes): Students shall discuss all the acts of selfishness that are the focus in the fourth section of the video and comment if there was any justification for any of these behaviors, and what was the right thing to do in every case.

Activity V (4 minutes): Students shall try to answer the following questions:

- What is the impact of the closure of **BC** in the third example?
- When is the network at Nash equilibrium in this case?
- What is the time it takes to cross each car in this case?

Activity VI (4 minutes): Students shall discuss the following question:

Does Braess's Paradox realize in real life, or is it just based on some theoretic examples?

Students who answered "yes" shall be requested to provide concrete examples. Those who answered "no" shall be requested to provide an explanation for their claim. **VII activity (4 minutes):** Students shall discuss the conclusion that was reached, and shall discuss the possibility of having some roads in their areas the closure of which may lead to improvement in the traffic.

- The teacher can add some activities, especially for distinguished students and for those who show interest in the subject. These might include wiring a an essay/report on Nash Equilibrium or Braess's Paradox and its various applications.