To game or not to game: teaching transportation planning with board games

Arthur Huang and David Levinson
Department of Civil Engineering
University of Minnesota
1/23/2012
null
Why board games?

Board games

- Transport networks
- Game economy
- Nexus between transport & land use
- Competition vs monopoly
- Financing
- Policy & deployment
- Technology

CE 5212
- Innovation & technology
- Road, transit, waterways, aviation
- Finance & forecasting
- Intermodalism & synthesis

CE 8214
- Economic actors as agents
- Demand & supply
- Negative externalities
- Competition & concentration
- B/C analysis

Source: http://nexus.umn.edu/Courses/ce5212/
http://nexus.umn.edu/Courses/ce8214/
Theory: dimensions of learning and teaching styles  
(Felder and Silverman, 1998)

<table>
<thead>
<tr>
<th>Learning style</th>
<th>Corresponding teaching style</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category</strong></td>
<td><strong>Category</strong></td>
</tr>
<tr>
<td>Perception</td>
<td>Sensing</td>
</tr>
<tr>
<td></td>
<td>Intuitive</td>
</tr>
<tr>
<td>Input</td>
<td>Visual</td>
</tr>
<tr>
<td></td>
<td>Auditory</td>
</tr>
<tr>
<td>Organization</td>
<td>Inductive</td>
</tr>
<tr>
<td></td>
<td>Deductive</td>
</tr>
<tr>
<td>Processing</td>
<td>Active</td>
</tr>
<tr>
<td></td>
<td>Deductive</td>
</tr>
<tr>
<td>Understanding</td>
<td>Sequential</td>
</tr>
<tr>
<td></td>
<td>Global</td>
</tr>
<tr>
<td>Content</td>
<td>Concrete</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
</tr>
<tr>
<td>Presentation</td>
<td>Visual</td>
</tr>
<tr>
<td></td>
<td>Verbal</td>
</tr>
<tr>
<td>Organization</td>
<td>Inductive</td>
</tr>
<tr>
<td></td>
<td>Deductive</td>
</tr>
<tr>
<td>Student participation</td>
<td>Active</td>
</tr>
<tr>
<td></td>
<td>Passive</td>
</tr>
<tr>
<td>Perspective</td>
<td>Sequential</td>
</tr>
<tr>
<td></td>
<td>Global</td>
</tr>
</tbody>
</table>
Research questions

- Can board games improve learning in transportation planning courses (CE 5212, CE 8214)?
- Why and how do board games enhance students’ learning?
- What are the implications of games on transportation planning education?
Overview of the courses

- Graduate-level courses on transportation planning (CE 5212) and economics (CE 8214) from 2008 to 2011
- The class size: 10~25
- Students: graduate students from civil engineering and urban and regional planning at the University of Minnesota
- Student were told to play board games at a “Game Night” (with pizza provided by the instructor), fill out pre- and post-game surveys, and write an essay to reflect their learning experience.
The pre-game survey:
Understand students’ learning styles (part 1)

<table>
<thead>
<tr>
<th>Category</th>
<th>Variable</th>
<th>Mean</th>
<th>St. Dev</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td>age</td>
<td>25</td>
<td>3.4</td>
<td>21</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>gender</td>
<td>0.76</td>
<td>0.43</td>
<td>0 (female)</td>
<td>1 (male)</td>
</tr>
<tr>
<td></td>
<td>work years</td>
<td>0.62</td>
<td>0.49</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Learning styles</td>
<td>Sensing</td>
<td>2.22</td>
<td>1.03</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Visual</td>
<td>3.02</td>
<td>0.98</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Active</td>
<td>2.38</td>
<td>1.22</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Sequential</td>
<td>1.96</td>
<td>1.02</td>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>
The pre-game survey: Understand students’ learning styles (part 2)
The pre-game survey:
Understand students’ learning styles (part 2)
The pre-game survey:
Understand students’ learning styles (part 2)
The pre-game survey: Understand students’ learning styles (part 2)
<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Model Scenario</th>
<th>key mechanisms</th>
<th>Winning criteria</th>
<th>Exogenous variables</th>
<th>Network grid given</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Baron</td>
<td>Air</td>
<td>Early period of the US airline industry</td>
<td>Build airline networks</td>
<td>Maximum market share and cash</td>
<td>Air crash, fuel crisis, stock market, and recession</td>
<td>No</td>
</tr>
<tr>
<td>Metro</td>
<td>Rail</td>
<td>Early period of Paris railroads</td>
<td>Build railroad</td>
<td>The player who builds the longest rail line</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Rail Baron</td>
<td>Rail</td>
<td>Early period of US railroads</td>
<td>Purchase existing rail roads and deliver goods by rail</td>
<td>The first player returning home with no less than $20,000 in cash</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Rail Tycoon</td>
<td>Rail</td>
<td>US railroad from 1830s</td>
<td>Build railroads at a deliver goods</td>
<td>When cities have no more goods left, the player with the most victory points wins.</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Empire Builder</td>
<td>Rail</td>
<td>US railroad history</td>
<td>Build railroads and deliver goods</td>
<td>The first player who connects six major cities and has $ 250 million cash.</td>
<td>Half shipping rate, floods, Derailments</td>
<td>Yes</td>
</tr>
<tr>
<td>China Rail</td>
<td>Rail</td>
<td>Early period of China railroads</td>
<td>Build railroads and deliver goods</td>
<td>The first player who connects four major cities and has $ 250 millions cash</td>
<td>Half shipping rate, floods, party congress, taxes, strikes</td>
<td>Yes</td>
</tr>
<tr>
<td>1870</td>
<td>Rail</td>
<td>Railroads in Trans-Mississippi area</td>
<td>Auction, stock exchange, operation of companies, corporate merging, build tracks, and run trains</td>
<td>When any player goes bankrupt or the bank runs out of money, the player with the greatest personal holdings wins</td>
<td>stock market and companies’ merging</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Example: Empire Builder

The rules:

1. Before the game, one player is selected as the banker and distributes $50 million to each player.

2. Players compete to build rail tracks, upgrade trains, and deliver goods on trains.

3. Winning condition: (1) several major cities are connected with one continuous line of track; (2) the player has at least $250 million in cash at the end of a turn.

Network grid given

Players: 2~6

Players draw tracks with wipe-off crayons

The network building process

Source: http://www.boardgameinfo.com/review/10/10039-Empire-Builder
Students’ evaluation of the games

Hard
- Empire Builder
- Rail Tycoon

Easy
- Metro
- Rail Baron
- China Rails
- Air Baron

Frustrating
- 1870
- Rail Tycoon
- Empire Builder

Satisfying
- Metro
- Rail Baron
- China Rail
- Air Baron

Dull
- 1870
- Empire Builder
- Metro

Stimulating
- Rail Tycoon
- Rail Baron
- China Rail
- Air Baron
Hypothesis

Board games, by matching the characteristics of the students with active, visual, sensing, and sequential learning styles through active game experience, produce greater learning outcomes for these students.
Yup, game time (with pizza served)
## Quantitative analysis

**Dependent var:** \( \log (\text{sum of effectiveness scores}) \)

Number of students: 50

<table>
<thead>
<tr>
<th>Independent var</th>
<th>Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAVS group</td>
<td>0.38 (0.16) **</td>
</tr>
<tr>
<td>Level of stimulation</td>
<td>0.09 (0.03) ***</td>
</tr>
<tr>
<td>Level of easiness</td>
<td>0.01 (0.03)</td>
</tr>
<tr>
<td>Level of satisfaction</td>
<td>-0.02 (0.03)</td>
</tr>
<tr>
<td>No. of learning styles</td>
<td>0.03 (0.04)</td>
</tr>
<tr>
<td>Age</td>
<td>0.02 (0.01)</td>
</tr>
<tr>
<td>Male</td>
<td>0.14 (0.11)</td>
</tr>
<tr>
<td>Grad student</td>
<td>0.06 (0.11)</td>
</tr>
</tbody>
</table>

*Sum of students’ self-evaluation scores on enhanced learning, improved understanding, overall learning experience, knowledge on network deployment, forming opinions on transportation planning, and effectiveness of board games as a teaching tool.*

*Student who is either moderately/highly visual, moderately/highly sensing, moderately/highly active, or moderately/highly sequential.*
# Quantitative analysis

Correlation tests of students learning styles

<table>
<thead>
<tr>
<th>Learning Style</th>
<th>Visual</th>
<th>Sensing</th>
<th>Active</th>
<th>Sequential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual</td>
<td>1</td>
<td>0.20</td>
<td>0.24 *</td>
<td>0.10</td>
</tr>
<tr>
<td>Sensing</td>
<td>0.20</td>
<td>1</td>
<td>0.37 **</td>
<td>0.30 *</td>
</tr>
<tr>
<td>Active</td>
<td>0.24 *</td>
<td>0.37 **</td>
<td>1</td>
<td>0.09</td>
</tr>
<tr>
<td>Sequential</td>
<td>0.10</td>
<td>0.30 *</td>
<td>0.09</td>
<td>1</td>
</tr>
</tbody>
</table>
Qualitative analysis

Students were asked to write up their findings on network growth from their game experience.

“Incentives for players include building railways and connections to cities that have the potential for the highest usage. Other incentives included a commission on commodities that are presented on load cards. Commissions such as jade and oranges yield higher commissions in certain regions than say tourists or oil in other parts of China. These commissions provide incentives for players to construct railways to certain areas, depending on potential commissions.”

“[The game] showed slow initial growth while resources were developing, rapid economic growth when the potential existed for it, and slower operations during the maturity phase. It demonstrated the mergers and acquisitions characteristic of railroads in the twentieth century; furthermore, many strategies in the game correspond to actual business approaches.”

Reinforcing the S-curve theory taught in the class

“There was a strong incentive to not only build in increments but build in a region of the country. Players would build routes to all the cities in a region to hold control over those cities. If a player started building in the north, there would be incentives to stay in the north... There was also an incentive to build in the east part of the map. Cities were much more numerous and closer together... The incentive in the game was to build a railroad empire in the east and expand the lines to the west when the resources and demands were present to do so.”

“The game models transportation system development in Paris in the 19th century, i.e. The Paris Metro. The actual Paris Metro spent years in dispute and disagreement over where to build the first subway line. The game of Metro with its rules restricting how a card may be laid as a tunnel connection in some ways mimics the complexity that the early planners/engineers/developers experienced when committing to build the first tunnel connections under Paris.”

“if cities were not urbanized, there was a disincentive to build links to these cities.”

“One significant omission from the game is operating cost. This distorts economics analysis that players make each turn somewhat, as an operating charge would lead players to favor destinations reachable in fewer turns.”
Qualitative analysis

“Incentives for players include building railways and connections to cities that have the potential for the highest usage. Other incentives include the commission on commodities that are presented on load cards. Commodities such as jade and oranges yield higher commissions in certain regions than say tourists or oil in other parts of China. These commissions provide incentives for players to construct railways to certain areas, depending on potential commissions.”

“There was a strong incentive to not only build in increments but build in a region of the country. Players would build routes to all the cities in a region to hold control over those cities. If a player started building in the north, there would be incentives to stay in the north...There was also an incentive to build in the east part of the map. Cities were much more numerous and closer together...The incentive in the game was to build a railroad empire in the east and expand the lines to the west when the resources and demands were present to do so.”

“In reality, few--if any--rail roads were actually built on a pay-as-you-go financing model, and many major lines found themselves in bankruptcy soon after completion.”

“One significant omission from the game is operating cost. This distorts economics analysis that players make each turn somewhat, as an operating charge would lead players to favor destinations reachable in fewer turns” ....

The game models transportation system development in Paris in the 19th century, i.e. The Paris Metro. The actual Paris Metro spent years in dispute and disagreement over where to build the first subway tunnels. The game of Metro with its rules restricting how a card may be laid as a tunnel connection, in some ways mimics the complexity that the actual developers/developers experienced when committing to build the first tunnel connections under Paris.

“One significant omission from the game is operating cost. This distorts economics analysis that players make each turn somewhat, as an operating charge would lead players to favor destinations reachable in fewer turns.”

Summarizing the limitations of the game model

“if cities were not urbanized, there was a disincentive to build links to these cities.”

“One significant omission from the game is operating cost. This distorts economics analysis that players make each turn somewhat, as an operating charge would lead players to favor destinations reachable in fewer turns.”
Conclusions

- Transportation board games seem a good pedagogical tool in transportation education, especially for open-ended subjects such as transportation planning, policy, economics, deployment, and evaluation.

- Students who are either moderately/highly visual, sensing, active, or sequential, all else equal, seemed to benefit more from the game experience than those who are not.

- We recommend the Rail Baron, Rail Tycoon, and China Rails which keep appropriate levels of easiness, satisfaction, and stimulation.
Back-up slides
The pre-game survey:
Understand students’ learning styles  (part 2)

- Doing: 30%
- Watching: 28%
- Thinking: 21%
- Concrete exp: 4%
- N/A: 17%

- Moderately global: 33%
- Highly global: 29%
- Highly sequential: 27%
- Moderately sequential: 17%
- MILDLY SEQUENTIAL OR GLOBAL: 6%

- Moderately sensing: 43%
- Highly sensitive: 30%
- Highly intuitive: 24%
- MILDLY SENSING OR INTUITIVE: 7%

- Moderately visual: 38%
- Highly visual: 35%
- MILDLY VISUAL OR VERBAL: 17%
- Moderately verbal: 8%

- Moderately active: 39%
- Highly active: 24%
- MILDLY ACTIVE OR REFLECTIVE: 18%
- Highly reflective: 6%