Getting from A to B: Using an Interactive Display to Demonstrate Transportation Planning and Design Issues

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ABSTRACT

An ongoing challenge worldwide has been the need to attract sufficient numbers of new people into transportation careers. In trying to explain what transportation engineering is about, many people often find that examples of practical applications are particularly useful. In this way, people can become interested in the problem at hand first and then realize their real-world applications in transportation careers.

Recently some funds donated to the Civil and Natural Resources Engineering Dept at the University of Canterbury, New Zealand, were used to develop some interactive engineering displays for existing and prospective students. The first exhibit developed was a transportation board display, representing a landscape upon which a new road route was to be determined.

The metallic display surface is sub-divided into hexagonal sections, each with a "cost" reflecting the relative difficulty of constructing in that location (e.g. due to mountains, rivers, development, etc). Magnetic straight and curved road elements (each with a value reflecting the costs to road users) can then be placed on the display to create an alignment between the chosen end points. The aim for users of the display is to determine the optimal road alignment, in terms of minimal construction costs, road user costs, or both.

Since its creation, the display has been used in various locations, both on campus and at career expos. It has been immensely popular with visitors, many of whom get quite caught up in solving the problems presented. The potential for using this as a classroom tool for maths, science or geography classes at high school has also been identified. This paper outlines the development of the display, its applications to date, and the transportation lessons that it can highlight.

INTRODUCTION

An ongoing challenge worldwide has been the need to attract sufficient numbers of new people into transportation careers to replace existing staff and provide the resources for new transport initiatives (*1*). In trying to explain what transportation engineering is about, many people often find that examples of practical applications are particularly useful. For example, the TRAC-PAC2 program (*2*) uses a variety of software and model based teaching tools to introduce different transport-related problems to school students. In this way, people can become interested in the problem at hand first and then realize their real-world applications in transportation careers.

In 2004, some funds were donated to the Civil and Natural Resources Engineering Dept at the University of Canterbury in Christchurch, New Zealand. The benefactor, a former graduate of the department, requested that they be used to help develop some interactive engineering displays to engage and attract existing and prospective students. The department's Public Relations committee oversaw the use of the funds and the first exhibit developed was a transportation-related display (described below). This paper outlines the development of the display, its applications to date, and the transportation lessons that it can highlight.

ATTRACTING PEOPLE TO TRANSPORTATION

This task of attracting people to careers in transportation is made somewhat more difficult by the multi-disciplinary nature of transportation activities. This requires presenting a fairly complex explanation of what work is done in this field and also necessitates appealing to prospective recruits in a broad range of initial subject interests (e.g. engineering, planning, geography, economics, psychology).

While it is important to encourage people at high school into transportation careers, there are also considerable opportunities at university level to attract students. In a survey of over 1800 civil engineering undergraduate students, Agrawal and Dill (*3*) noted that over half of all responding freshmen were undecided about a specialization and the proportion of those stating a preference for transportation experienced the greatest growth (compared with other specializations) during the years at university.

In the United States, a key initiative to encouraging more high school students into transportation careers has been AASHTO's TRAC (Transportation and Civil Engineering) program (*4*). TRAC's key method of outreach is with volunteer transportation professionals delivering TRAC-PAC, which consists of a computer, electronic data collection and analysis instruments, hands-on modeling materials, and more than 30 activities based on real-world transportation problems. For example, students use the SimCity software to model land use zoning effects on transport, or create a simple traffic signal phasing sequence using a spreadsheet. The TRAC program also runs annual design-build competitions, where teams must use simple materials to construct a load-bearing bridge. The TRAC program has also been taken to other countries and adapted for use there, e.g. in South Africa (*5*).

Other promotional initiatives have involved creating special events or programs to introduce participants to transportation-related activities. These have included the *GoGirl!* events in Texas, a series of one-day workshops targeted specifically at school girls (*6*), and transportation-specific science competitions for high school students (*7*). Summer internships, where young people get to spend some work time with a transportation agency, have also been used as a way to introduce potential candidates to the careers they could have in transportation (*8*).

The internet has also allowed for the easier distribution of transportation promotional material and interactive games and tools. For example, *Go!* is a free, online magazine for teens and young adults that explores the world of transportation and the careers they can find there (*9*). Online software has also been created to allow students to interactively examine traffic modeling scenarios remotely (*10*) and undertake roadway geometric design (*11*), and similar online initiatives to the general public could be used to attract people to the challenges of transportation.

Interactive methods of presenting transportation information have been commonly used in public consultation exercises, e.g. using traffic model visualization to illustrate the impacts of different transport proposals (*12*). Similar tools have also been used for self-directed learning of pavement design (*13*). The same visual appeal of these techniques, their simplified representation of transportation issues and instant feedback can also be a useful way to introduce people to potential careers in transportation.

Although a number of the initiatives mentioned above involve the use of electronic hardware or software, it is certainly not a pre-requisite to a successful transportation promotion. Whilst typically convenient and flexible in how they can deliver the transportation message to audiences, there is often a considerable development and maintenance time involved with such hardware and software, generally requiring specialist skills to achieve this. More conventional "manual" initiatives can be equally as successful, particularly if they adhere to the key principles of conceptual simplicity, personal interaction and valid real-life examples.

THE TRANSPORTATION PROBLEM POSED

The display developed was conceived by the author and represents a landscape on which a new road route is to be determined. The landscape is divided into hexagonal grids, similar to many popular role-playing board games. Various natural and man-made features such as rivers, hills, and settlements are placed around the landscape. Straight and curved road segments, spanning one grid each, can then be connected to create a road alignment across the landscape.

Figure 1 illustrates the schematic landscape created for this display, as well as (to scale) examples of the straight and curved road segments in the top-left corner (the latter can curve left or right by 60°). Both the grids and the road elements have a numeric value:

- The number on each grid represents the **construction cost** to build a road here (higher where there are constraints such as hills, rivers, settlements, ecological areas, etc). For example, while the base cost for simple (flat, undeveloped) terrain is 1, grids near the river (where bridging would be required) typically have a cost of 7-10.
- The **road user cost** for each segment varies (2 for a straight, 3 for a curve) to reflect the relative costs of travel-time, vehicle operating (e.g. fuel), crash risk, etc.

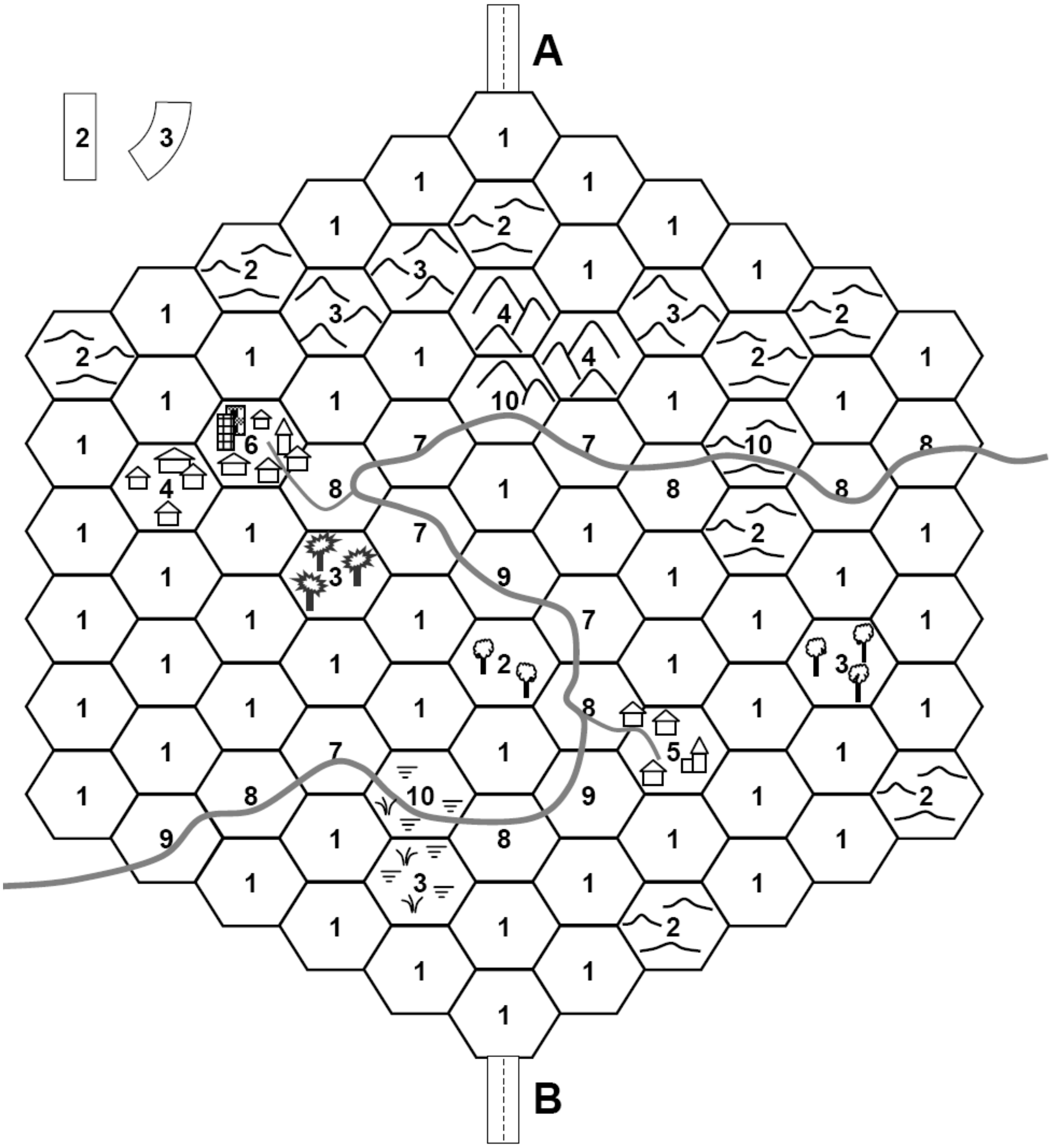


FIGURE 1 Landscape Layout Plan used in the Display

Using a combination of straight and curved road segments, the challenge is to determine an optimal route across the grid plan connecting the end points 'A' and 'B' (in this case at the top and bottom of the landscape, but potentially anywhere around the edges). The display lends itself to several slightly different but related challenges:

(i) What if we try to **minimize the road user costs** (i.e. the cost of the road segments)?

(ii) What if we try to **minimize the road construction costs** (i.e. the cost of the grids)?

(iii) What if we try to **minimize the combined (road user + construction) costs**?

(iv) What if **traffic volumes are doubled** (i.e. the road user costs are now **4** & **6** per segment respectively); which route minimizes the combined costs now?

Figure 4 (at the end of this paper) shows a sample of the final instructions produced to accompany the display. An example route is given to help explain how to calculate the necessary costs.

Transportation Principles Demonstrated

In its simplest sense, the display illustrates why we can't always just build a straight road from A to B. It highlights real-world problems that transportation professionals have to face, including difficult terrain and sensitive areas. It also emphasizes that the original construction cost is only part of the total costs to society. Typically nowadays, transportation jurisdictions will evaluate roading proposals not just on the construction and maintenance costs to the agency, but also the relative costs (or cost savings) to road users in terms of travel time, accidents, vehicle operating expenses, etc.

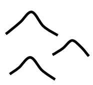
A series of possible discussion points have been identified for those supervising the exhibit to raise with visitors to or users of the display:

- A straighter route may not be the cheapest because of the construction costs involved.
- There are often many alternative routes with similar construction costs but with different implications for road user costs (and vice versa).
- Neither the route with the least cost in terms of road user or construction is the most optimal for both together (at least, in the default problem).
- Increased traffic volume has a big effect on the viability of more direct routes.

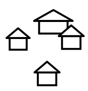
The display also illustrates the tension between agency and road user costs. Firstly, it is desirable to build roads as direct as possible, to minimize road user costs such as crashes and travel-time, by:

- Minimizing the use of curves
- Making as short a route as possible (i.e. fewest number of segments)

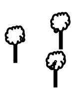
However, the display also highlights various constraints that have to be considered to minimize construction costs:



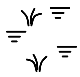
Terrain: It's harder to build direct routes in hilly or mountainous areas, where earthworks might be quite significant or grades quite steep



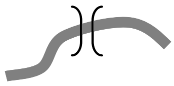
Existing Development: It usually involves more time and cost to build in locations that are already developed (e.g. urban areas)



Environmental Features: It may be more difficult to build through areas of dense vegetation or sensitive ecological and archaeological zones



Ground Conditions: Some areas may have very poor, soft ground to build on (e.g. swamps) or very hard terrain (e.g. rock)



Water Features: It costs considerably more to build roads across water features such as rivers

In this relatively simple scenario, a wide range of transportation issues are introduced for the participant to consider, such as:

- Geometric design and route planning
- Environmental assessment and mitigation of transport options
- Road construction and site considerations
- Road safety improvements
- Transport economics (incl. road user costs) and project evaluation

DISPLAY CONSTRUCTION DETAILS

Initially the envisaged concept was a floor-based display (approximately 2 m or 7 ft square), on which participants could walk over and place the required road segments. However, in discussion with a developer of other interactive displays for science exhibits (who ended up building this display), it was recognized that a vertical-standing display would have much more impact from a distance.

The developer proposed a steel triangular frame system onto which a series of metallic vertical display panels would be attached. Four connecting triangular frames provided a base behind the display panels. The entire assembly comprises 32 frame pieces with welded bolts and drilled plates, all connected by wing-nuts. A coding system was marked on the frame components to ensure correct connection.

The schematic landscape shown in Figure 1 was converted into a more attractive color layout by a graphic designer. This image was then printed onto nine thin steel panels arranged in a 3-by-3 grid covering approximately 1.8 m or 6 ft square. Each panel has a central rear block attached that slots between the framing, and magnetic backing strips are used to secure the sheets to the frame.

Approximately 30 acrylic plastic straight and curved road segments with magnetic bases (similar to “fridge magnets”) were created for placing on the display panels, to create an alignment between the designated end points (Two smaller magnetic pieces marked ‘A’ and ‘B’ are used for these). A feature of the road segments is the circular clear pane in the centre of each, enabling easy reading of the underlying landscape construction cost.

Figure 2 shows the completed display set up at a student careers expo; note the 3-by-3 grid of display panels. Accompanying instructions and other text were printed, laminated and affixed to the display using tape. All up, construction of the display cost about NZ$5500 (~US$4000) plus time for preparation of printed resources and graphic design.

A note sheet was also prepared for the supervising staff, explaining the display challenge, possible solutions, and the concepts it introduced. Solutions were provided for the default case where ‘A’ and ‘B’ are at the top and bottom of the display. It is, however, feasible to place the two small end road pieces in different locations around the map edge and have visitors try to determine the optimal routes between them instead.

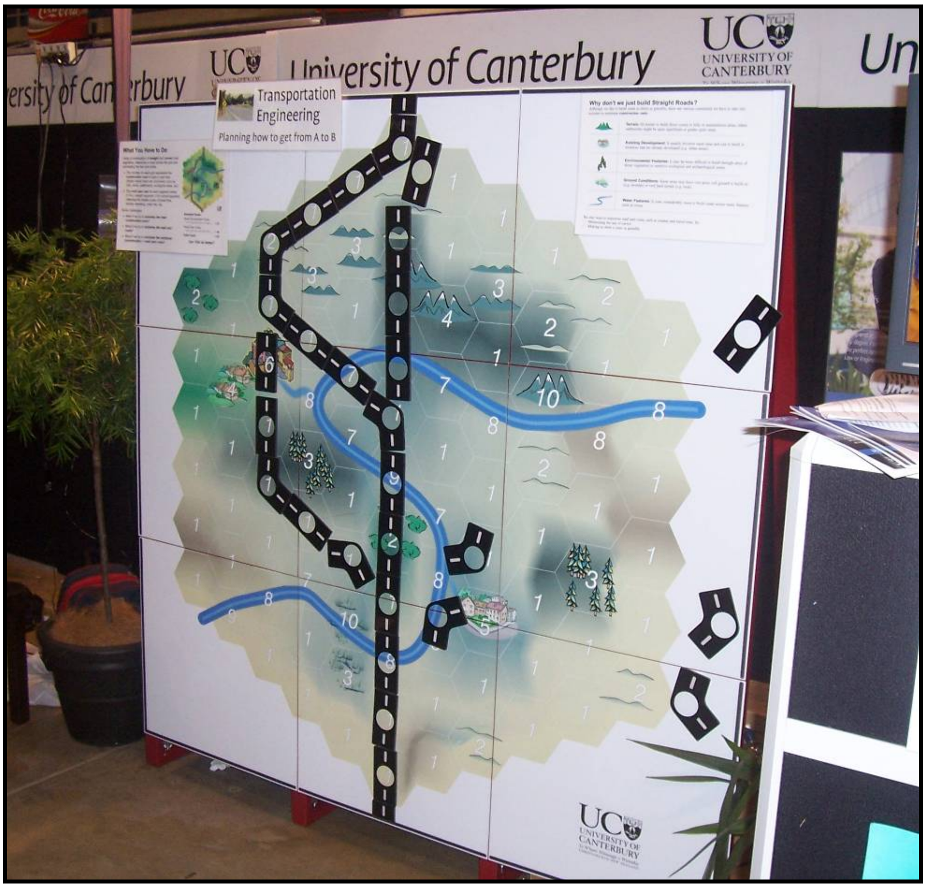


FIGURE 2 Constructed Transport Display

Other Possible Construction Alternatives

Currently the display requires people to manually calculate the total cost of their determined alignment. Already a computer science colleague at the university has expressed interest in developing a software version of the same problem that would automatically calculate the cost of the alignment (and the respective construction and road user components). This could be set up beside the physical display to enable quick calculation of alternative options.

Another possible design alternative considered was to create a base landscape and road segments with interlocking electrical connectors. These could create a connected circuit between ‘A’ and ‘B’, once sufficient road segments completed the link. By using resistors of different value for both the road segments and the underlying grids, the total cost could be calculated and automatically displayed on an LED display.

APPLICATIONS TO DATE

Since its creation, the display has been used in a variety of locations, both on campus and elsewhere:

- It was installed at the annual Christchurch high school careers expo (catering typically for year 11-13 students), as part of the University's display on engineering careers (see Figure 3). Visiting students were able to try out the display while supervising staff discussed with them possible related career options.
- It was set up for over a month in the Civil and Natural Resources Engineering Department's reception area, allowing waiting students and visitors the chance to try it out.
- It was installed in the Engineering Library for about six weeks, enabling a wider range of technical students to encounter it. A "best score" sheet was posted by the display, so that visitors could record their attempts to get the most optimal solutions.
- During a visit to the university by year 7-8 science extension students to learn about engineering, a session was held where the students attempted to solve the challenges posed by the display. The students had the opportunity to work on their solutions directly on the display, after which the best solutions were identified, followed by related discussion afterwards. Despite the younger age of these students (10-12 years old), they appeared to have no trouble picking up the nature of the task at hand and solving it.

FIGURE 3 Transport display at a high school careers expo

Informal observations of these events have shown the display to be immensely popular with visitors, many of whom get quite caught up in solving the problems presented (even if they have subsequently declared that they have no interest in transportation or engineering!).

A paper form of the same problem was also given to undergraduate students as an assignment in an introductory transportation engineering course. The same exercise has also been used as a tutorial for a graduate geometric design course. The relative simplicity of the underlying concepts make it an ideal introduction to transport design and planning issues, prior to learning about more rigorous design and evaluation methods and the use of detailed road design packages.

Other Potential Applications

Although not yet tried out, the potential for using the display as a classroom tool for math, science or geography classes at high school has also been identified. Ideally the display could be shipped to a school, with accompanying resource material to both explain the concepts involved and possible related careers.

The competitive nature of the challenges posed allows such a display to also be used to collect contact names for follow-up information. Visitors to the display could be asked to determine the lowest costs for the various challenges and enter a draw for a prize. Those responding could then be followed up later with more information about transportation or engineering careers.

Practical Issues

Although the use of the display to date has easily met our expectations, there are a few practical issues that need resolution, possibly in any future reincarnation:

- The steel construction, while making the display quite robust, does introduce a significant weight element. This has implications both when adjusting the display's position and when transporting the disassembled pieces. The magnetic segment connection system has somewhat dictated this design, although in hindsight there may be more lightweight solutions that are equally acceptable. For example, a Velcro connection system may be possible.
- Although sturdy, the steel panels have proved to be not infallible. The noticeable weight of each panel has caught the occasional person unaware when assembling the display, resulting in dropped panels. This has caused a few "kinks" in the edges of the panel and that has made it difficult for some road segments straddling two uneven panels to make an adequate magnetic connection. Manual repairs (e.g. using pliers) have proven only partially successful to date.
- Similarly, the acrylic plastic road segments are prone to people dropping them, and at least two have cracked as a result. To lessen this for now, some soft fabrics are now placed directly below the display (e.g. old towels), but this doesn't enhance the appearance of the display. A strip of thick carpet may be a tidier solution; alternatively rubber-based road segments may be more robust.

- To date, the display has been transported to sites with all of its component pieces disassembled and individually moved. This has been only a minor inconvenience for local sites under the supervision of university staff, but would be impractical for shipping further afield, especially to outside parties. Plans are underway to obtain some custom-made bags and tubes to hold the panels, frames and other equipment efficiently.
- Construction of the display takes approximately 20-30 minutes, mainly because of the large number of wing-nuts that have to be screwed and tightened. For future versions, it might be more pragmatic to use a quicker method of assembly.

Because of the small components involved in the display and the potential for vandalism, it is prudent that the display is not placed in an unattended location (e.g. a public foyer overnight). To date, the display has only been used in locations where responsible staff are nearby and it is secure after hours. Often, having staff nearby is logical anyway, as they also serve to provide guidance to those using the display.

CONCLUSIONS

The development of this interactive transport display has proven to be a useful tool for promoting transportation and engineering to prospective students in New Zealand. The apparent simplicity of the challenge presented allows most people of all backgrounds to “get it” fairly quickly, while still allowing more complex related topics to be introduced to the participants. Although some practical issues have been identified that could be improved upon, they have not been insurmountable. The concept presented could also be applied to other interested jurisdictions and the author would be happy to provide further advice to other parties.

ACKNOWLEDGEMENTS

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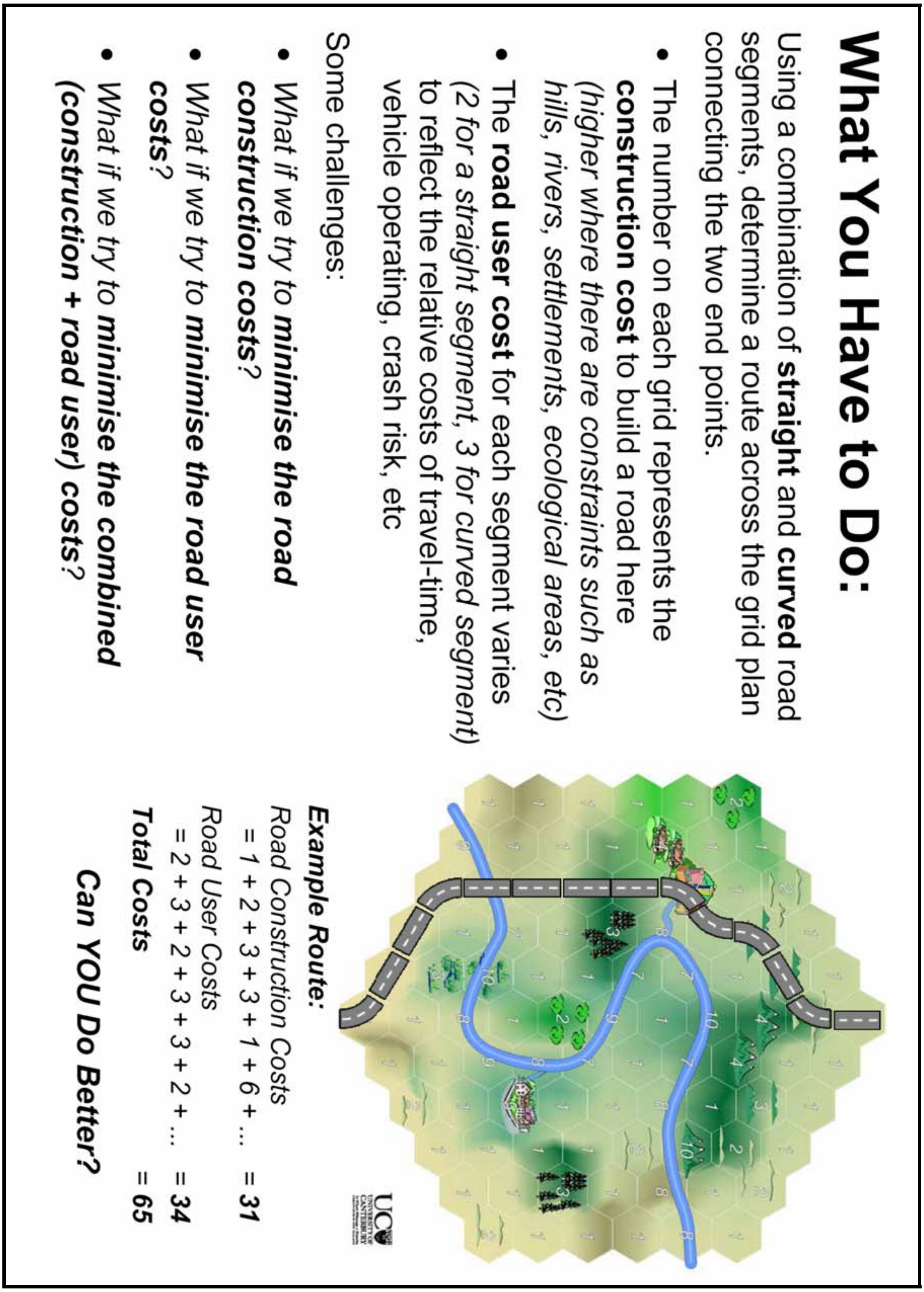

FIGURE 4 Example of Instructions used to Explain the Challenge