Findings

The transport ticketing board is a physical, interactive learning aid that presents a dynamic and interactive categorisation framework of ticketing types to help educate students and transport professionals about the choices faced when designing passenger transport ticketing, and hence inform the next generation of systems. The learning aid comprises tickets collected from around the world displayed on an electronic board. It was developed to encourage students and visiting public transport professionals to discuss issues around designing optimal transport ticketing systems. It highlights the complexity and consequent diversity of systems globally which indicates the importance of context in making choices.

1. Questions

Ticketing systems, also known as Revenue or Fare Collection Systems are mechanisms by which public transport users pay for the right to travel (Harvey 2015). Transport tickets act as proof of entitlement to travel for the user and those that control the transport system (Glover 1999). Well-designed ticketing systems are fundamental to managing public transport operations, but what does the ‘optimal’ ticketing system look like, and why is there such a diverse range? The board offers new insights about the range of choices available to transport practitioners and the implications of those choices on achieving often conflicting user and operator outcomes.

We ask the question:

How do we build something to encourage students and practitioners to talk about issues around the choices and trade-offs facing designers of passenger transport ticketing systems face; the factors influencing these choices; and how ticketing systems look in the future?

2. Methods

We analysed ‘artefacts’ (i.e. appropriate physical manifestations of the process under investigation, in this case public transport tickets from around the world) formed the primary data. We adopted the ‘found object’ practice to reinterpret values, metaphors or the status-quo through the outputs from objects (Chilvers and Glaves-Smith 2015; Harrison and Wood 2002). We used the approach previously to help students explore different methods for managing car use (see Enoch and Warren 2020).
This analysis comprised seven steps.

Step 1: Transport tickets (>100) from many modes and countries were collected to determine a broad range of ticketing system characteristics.

Step 2: We developed a categorisation framework based on the collection analysis and on literature (e.g. Vuchic 2005; Fleishman et al. 1996). Ticketing systems were characterised against twelve attributes – nine charging-related and three media-related (see Table 1) – and each attribute provided a number of options for the designers of ticket systems to make. Overall, 55 attributes result in 6.08 million possible outcomes!

Step 3: The framework was graphically arranged with each attribute represented like a metro line on a network map, and a series of ‘stations’ representing discrete ticketing system design options that could be chosen (see Figure 1).

Step 4: We selected 16 tickets to efficiently cover the design options, whilst covering many modes and countries of origin and these were categorised against each of the twelve attributes and ‘plotted’ for each ticket in a spreadsheet (Supplementary S1).

Step 5: The performance of each design option for each attribute was assessed against six ticketing system policy objectives – three from a user perspective, and three from an operator perspective in a spreadsheet (see Figure 2 for examples and Supplementary S2).

Step 6: The results were displayed on a purpose-built electronic ‘ticketing board’ which is 1.2 metres wide and 0.9 metres high and comprises a printed circuit board controlled by the two spreadsheet-based algorithms. Actioned by 34 push buttons, 89 LEDs, and electric wire, the board has two key functions. The first allows users to categorise each ticket (arranged around the network map). On pressing the ticket, one LED per attribute line lights up to illustrate the specific characteristics of the ticket being pressed. The second allows users to explore how each design option for a selected attribute performs against each policy objective (a dim light means it performs ‘poorly’, a medium light ‘average’ and a bright light ‘strongly’). From this, the user can visually compare how the design options for the distance discrimination attribute (i.e. flat fare, zonal fare, stage-based fare and mileage-based fare) perform against the simplicity and revenue maximisation policy objectives for example. See Figure 3 to see the board in use.

Step 7: Implications for policy makers can be determined. As of 31 July 2021, informal discussions have resulted from approximately 20 academic and transport operator colleagues and 150 undergraduate transport students.
Table 1. Twelve attributes in two domains linked to ticketing systems.

| Attribute | Design options | Description |
|-----------|----------------|-------------|
| **Number of rides permitted** | single | Valid for single-leg trip |
| | through ticket | Valid for multi-leg one-way trip |
| | return | Valid for trip there and back |
| | fixed trip carnets | Valid for fixed number of defined trips |
| | stored value card | Valid for the number of trips equivalent to the value on the card |
| | unlimited trips (period ticket) | Valid for any trip (on the stated service) |
| **Duration of ticket** | length of single trip(s) | Valid for a single trip |
| | transfer | Valid for an end to end trip with includes a transfer within a limited amount of time |
| | day ticket | Valid for unlimited trips on a single day |
| | multi-day ticket | Valid for unlimited trips in a limited period, usually 3 or 5 days |
| | season ticket | Valid for unlimited travel for a set period of time, typically 1 week, 1 month, or 1 year |
| | unlimited period | A ticket with no time constraints, sometimes called ‘open’ ticket |
| **Distance discrimination** | flat fare | A single price for the fare |
| | zonal fare | Prices increase or decrease across geographical zones or physical boundaries |
| | staged fare | Prices which are discretely set according to destination or boundary; similar to zonal but usually along a single route |
| | mileage-based fare | Prices increase according to the distance travelled |
| **Integration level** | single operator/ single mode | Fare is linked to a single operator, single mode |
| | single operator/ multi-mode | Fare is linked to one operator for multiple modes |
| | multi-operator/ single mode | Fare is eligible for all providers using a single mode |
| | multi-operator/ multi-mode | Fare is eligible for all providers and all modes |
| | multi-service | Fare allows related services or provides benefits to user, some of which may be non-transport |
| **Number of users** | one person | Fare or ticket is valid for one person |
| | group tickets | Fare or ticket is valid for number listed on artefact |
| **Ticket exclusivity** | transferable | Fare or ticket can be given to another user |
| | non-transferable | Fare or ticket is only valid for named user |
| **Type of individual** | non-differentiated | Same fare for all users |
| | concessions | Fare changes based on user characteristics (e.g. student, disabled) or trip characteristic |
| **Differentiation by time** | valid anytime | Fare or ticket is valid at any time |
| | peak and off peak | Fares typically are higher during peak periods and off peak tend to have lower fares |
| | crude yield management | Fares which are adjusted, by bands, according to level of bookings, or potential demand, on a service |
| | real time yield management | Fares which are adjusted according to actual demand at the time of booking |
| **Ancillaries** | all in tickets (bundled) | Ticket or fare which includes all ‘extras’ bundled into a single price (also called bundled services, or package); usually only one class of ticket |
Fare structuring domain: 9 attributes

| Attribute                                      | Description                                                                 |
|------------------------------------------------|-----------------------------------------------------------------------------|
| ticket segmentation (packages)                 | Tickets or fare which are segmented according to services provided          |
| disaggregated service attributes               | Tickets or fares which are highly unbundled and each service is paid for separately |

Payment and Control Domain: 3 Attributes

| Timing of payment (POS)                        | Description                                                                 |
|------------------------------------------------|-----------------------------------------------------------------------------|
| in advance (pre-trip)                          | transaction occurs before the trip, usually pre-booked                      |
| at the barrier                                 | transaction takes place at gate or barrier                                  |
| boarding the vehicle                           | transaction takes place as user boards the vehicle                          |
| on board the vehicle                           | transaction takes place on the vehicle                                       |
| exiting the vehicle                            | transaction take place as the user leaves the vehicle                       |
| post trip payment                              | transaction takes place after journey is completed                          |

| Ticket medium                                  | Description                                                                 |
|------------------------------------------------|-----------------------------------------------------------------------------|
| cash (exact fare)                              | Fare required is the exact amount in coin or paper notes                     |
| cash (change given)                            | Fares can be paid in coin or note form and change is given                   |
| tokens (weight)                                | Tokens must be purchased to use the system                                   |
| tokens (chip)                                  | Token which contains a chip and must be purchased to use the system         |
| printed tickets (visual)                       | Printed ticket provided to gain access to system                             |
| printed tickets (barcode)                      | Printed tickets with scannable codes which permit access (also includes QR-codes) |
| ticket (magnetic strip)                        | Tickets with a magnetic strip usually                                       |
| contact smartcard (chip)                       | Dedicated plastic card with embedded chip is used to record all tickets and trips; funds can be pre-loaded or transferred electronically |
| contactless smartcard (RFID)                   | Dedicated card with RFID which allows contactless ticketing; has similar functions as above |
| contactless bank card (RFID)                   | A national issued bank card which uses RFID to pay for transactions and the transport system simply charges the account linked to that bank card. |
| mobile phone                                   | Payment is achieved through an application within the mobile phone using either QR code scans, or other means of electronic transfer |

| Control methods                                | Description                                                                 |
|------------------------------------------------|-----------------------------------------------------------------------------|
| open system control                            | There are no barriers or controls for users within the transport system.    |
| closed entry, open exit                        | A transport system which uses entry checks, such as gates, but allows barrier-free egress. |
| open entry, closed exit                        | A transport system with no entry barriers but employs gates, barriers or checks during egress to ensure payment was completed. |
| fully closed system                            | A transport system which requires users to log both the start and end of the journey typically using physical gates, or points of contact for tickets/devices. |

3. Findings

The ticketing board reflects the huge array of different ticketing systems globally. Each system has evolved according to its own unique context and policy goals and typically created a bespoke solution. We demonstrate privately-operated systems in the UK seek to maximise revenues through multiple fare
differentiation strategies and strong enforcement regimes requiring high-tech equipment for collecting, monitoring and enforcing payment. In Europe, goals of encouraging users for public policy reasons and prioritising service efficiency mean much simpler fare structures and less ticketing infrastructure, but a higher need for subsidy. Differences are also shown between modes. City-based, short-distance mass transit modes such as metro systems where changing services and paying small amounts close to, or at the time of departure may
be features of use, use cash or smart card payments and a simple fare structure is adopted. By contrast, fares are often much more differentiated for longer distance and more occasional trips made on services like airlines or interurban rail.

The board exhibits recent technologies (e.g. smartphones, contactless payment) that are rapidly changing this landscape, and so promotes discussion of possible futures. Interestingly one group reported that new systems will see specialist suppliers delivering a ‘one-size-fits-all’ approach to pricing and ticketing, where the need to prioritise one policy objective at the expense of another may well be much reduced.

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SUPPLEMENTARY MATERIALS

Supplementary Materials 1
Download: https://findingspress.org/article/28926-ticketing-artefacts-and-designing-fare-collection-systems/attachment/72479.xlsx

Supplementary Materials 2
Download: https://findingspress.org/article/28926-ticketing-artefacts-and-designing-fare-collection-systems/attachment/72830.xlsx