VISUALISING ERGONOMICS DATA FOR DESIGN

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ABSTRACT
Previous research has found that the use of ergonomics data has been relatively unpopular among designers, due to the fact that information is usually presented in a non-visual format. To encourage the uptake of ergonomics data, this research explored the potential of representing information in a more visual and dynamic way, through the use of the Cambridge Engineering Selector (CES). Information was supported by pictograms, illustrations and graphs that were linked to the relevant data sets. The resultant tool ErgoCES also features a 'People Universe' and a 'Product Universe' database as a repository for information on human data case studies. The tool was tested with design students and professionals for user feedback. The results suggested that ErgoCES had made ergonomics data more receptive for students and design practitioners. It was also found that scenarios and case studies were highly popular among the participants. Lastly, all the design students and 79% of the professionals indicated that they would use the tool when it becomes publically available.

Keywords: ergonomics data, Cambridge Engineering Selector (CES) , visualisation, designers

1 ERGONOMICS DATA FOR DESIGN: THE PROBLEM
Previous research has found that ergonomics data has not been effectively used by designers [1-3]. It has been observed that the root of current problems is due to two factors: the lack of useful information; and representing data in an inappropriate manner. This paper deals with the second aspect.
This is supported by [4] who noted that existing ergonomics data has often been presented in a non-graphical format that makes it difficult for designers to understand [4]. This may be because the training of ergonomists differs from that of designers. For instance, ergonomists have a background in science, such as psychology or mechanical engineering. They are often familiar with the use of numbers and structured diagrams; whereas designers are usually visual thinkers who are more attuned to the use of images and pictorial information. The aim of this project is to provide designers with better access to ergonomics data; and to present such information in a more effective way. With this in mind, the authors explored the use of the Cambridge Engineering Selector (CES) as a potential medium.

2 VISUALISING ERGONOMICS DATA: THE DEVELOPMENT OF ERGOCES

2.1 The CES software
The Cambridge Engineering Selector (CES) is the brainchild of Professor Michael Ashby at the University of Cambridge. It was adopted as the platform for ErgoCES, as it could visualise scientific data, and has strong potential as a teaching tool [5]. The software incorporates functions such as browsing and searching. In addition, CES is able to present and highlight numerical values within a small pictorial space; and has the ability to make large data sets coherent and encourage the audience to compare different pieces of data. Lastly, the software can be configured to reveal slices of data with different levels of detail.

2.2 ErgoCES Phase 1: Conceptual design and early evaluation
At the start of the research project, user studies were undertaken to understand designers' perspectives and their preferences on tool use. Several concepts were developed, including '2D people' (two-dimensional anthropometric data), '3D people' (human-modeling), 'ErgoCES' (ergonomics data displayed using the CES interface), 'Ergo-Lab' (a physical lab to conduct ergonomics research) , 'People Universe' (a collection of population data), 'Product Universe' (a collection of product case

studies), ‘People space’ (a virtual space for exchanging relevant information) and ‘Posture sourcebook’ (a range of postures) [7]. Three concepts, ‘ErgoCES’, ‘People Universe’ and ‘Product Universe’ were then chosen to be combined as a holistic tool. To reflect the change, it was renamed ‘ErgoCES’ – a comprehensive ergonomics tool for designers.

2.3 ErgoCES Phase 2: Constructing the database

In the next stage of development, the authors focused on building the database, comprising ‘People Universe’ and ‘Product Universe’. ‘People Universe’ contains information on anthropometric data. The main purpose is to provide designers with a diverse range of anthropometrical information. The main data source is derived from ‘Body space’ [8] which contains 38 data tables with 36 attributes (e.g., body weight, hip height) that can be cross-compared (e.g., from different countries, male data and female data). Complementary datasets such as ‘extra-ordinary ergonomics’ [9] and ‘Older adult data’ [10] were also utilised.

The ‘Product Universe’ database was developed from the authors’ understanding that many designers started their designs from studying existing products on the market. This inspired the authors to create a database that would be closely linked to the people database, so as to allow designers to be able to seamlessly search for product information, and view relevant ergonomics and user data. The Brunel University’s undergraduate major projects were used as the main source of the product database. This is supported with the fact that major projects at Brunel University required in-depth ergonomics and human factors research.

The major projects that were completed between 2006 to 2010 were selected, spanning the areas of consumer electronics, sports equipment, medical devices to assistive devices, etc. The major reports (typically between 12,000-20,000 words) were converted into short case studies (between 1500 and 4000 words). In addition, key words defined as “attributes” (e.g., abstract, key quotes, names of designers, images, introduction, methods, results, conclusions, references etc), so they can be searched from ErgoCES. The typical search parameters include terms such as product types, keywords, identification numbers or designer names. There were 38 case studies included in the ErgoCES prototype.

With the visualisation function of the CES software, we were able to create new information from existing data, for example, the stature groupings (Figure 1) of the British children, adults and elderly which clearly show the patterns not directly visible from the original tabulated data.

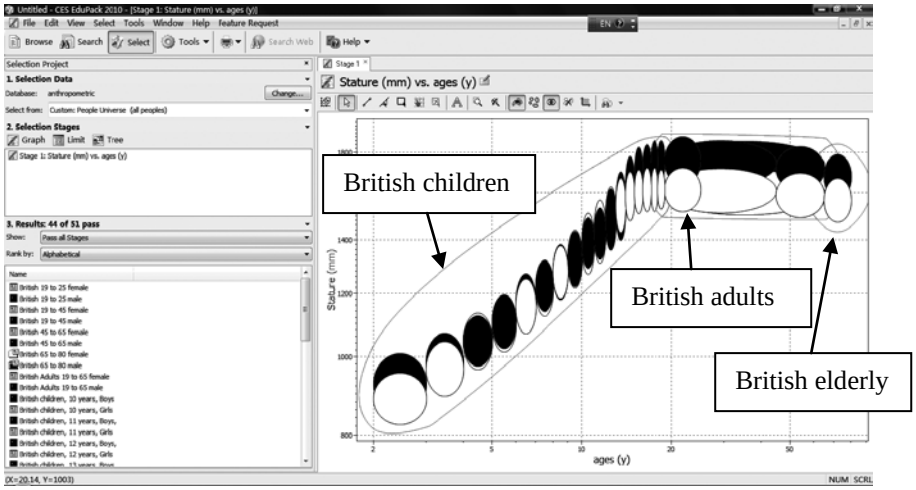

Figure 1. Comparable stature groupings of British people

2.4 ErgoCES Phase 3: Improving the visual interface

The third phase of the development centered on improving the visual interface of the tool to make it more designer friendly. The first step was to improve the display of the database by adding visual images so that users would be able to better related to the information. For example, using maps to show Regional Anthropometric Data (Figure 2).

Figure 2. Images to illustrate the context of existing data

The second step was to add images to illustrate specific measurements, such as the use of arrows in Figure 3 to denote the distance for measurement. This allows designers to understand the associated terms in a simplified way.

Figure 3. Figures with measurement indicator arrows

The third step was to add illustrations of specific scenarios, such as shown in Figure 4.

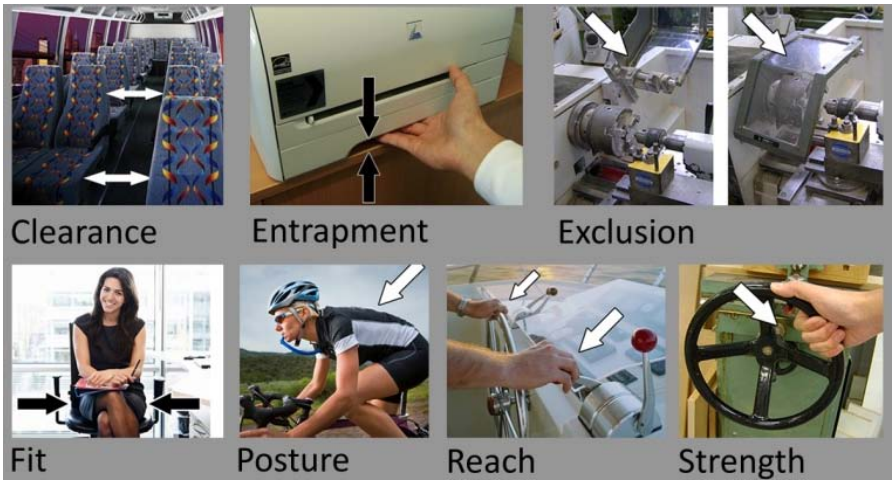

Figure 4. Scenarios

3 EVALUATING THE ERGOCES

Following the development of ErgoCES, the next step was to undertake a series of evaluation studies with design students and professionals. This took place over a period of two months, involving 39 final design undergraduate students at Brunel University, 5 MSc (Integrated Product Design) students, and 39 professionals (designers, design researchers, and ergonomists from eight companies and organisations). In each session, a brief demonstration of the ErgoCES tool was given to the participants before allowing time for a hands-on experience. The students were provided computers that had the pre-installed tool (Figure 5).

Figure 5. Evaluation with design students

For the professional evaluation, laptops were used as a more portable medium (Figure 6). In both student and professional testing sessions, the same version of ErgoCES was used.

Figure 6. Evaluation with professionals

The participants were then asked to fill in an evaluation questionnaire and the summary results are shown in Table 1.

Table 1. Feedback to the ErgoCES prototype

	Very difficult	Difficult	Average	Easy	Very easy
	Very poor	Poor	Average	Good	Excellent
Rate the overall quality of information	0	1	9	42	25
Rate the overall quality of user interface	0	4	24	35	14
How would you rate the overall ease of use?	0	3	14	47	9
Were the descriptors clear and easy to understand?	0	1	11	46	14
How would you describe your experience when searching for information?	0	3	24	33	5
How would you rate the presentation of information?	0	2	19	43	9
How easy did you find it to navigate through the database?	0	2	21	34	10
How would you rate the usefulness of the graphs?	0	0	13	39	18
	Yes		No		
Has ErgoCES raised awareness of inclusive design?	48		29		
Has inclusive design information been made more accessible?	68		11		
Would the tool be beneficial when designing?	68		6		
Will you use ErgoCES when it becomes widely available?	69		6		
Has ErgoCES raised awareness of inclusive design?	48		29		

The results in Table 1 show that feedback from the respondents was largely positive. The breakdown in percentages of feedback from the different evaluation groups (i.e., undergraduate design students, MSc design students, and professionals) is shown in Table 2.

Table 2. Positive feedback breakdown by groups and percentages

UG: Undergraguates / PG: Postgraduates / Prof.: Professionals

	Positive feedback (Easy/Good)			Very positive feedback (Very easy/Excellent)		
	UG	PG	Prof.	UG	PG	Prof.
Rate the overall quality of information	62%	20%	44%	36%	80%	18%
Rate the overall quality of user interface	44%	60%	38%	26%	40%	5%
How would you rate the overall ease of use?	56%	80%	54%	21%	20%	0
Were the descriptors clear and	56%	40%	56%	28%	20%	5%

easy to understand?						
How would you describe your experience when searching for information?	46%	20%	36%	13%	0	0
How would you rate the presentation of information?	51%	80%	49%	15%	20%	5%
How easy did you find it to navigate through the database?	46%	60%	33%	18%	20%	5%
How would you rate the usefulness of the graphs?	51%	100%	36%	31%	0	15%
	Yes			No		
Has ErgoCES raised awareness of inclusive design?	77%	80%	8%	21%	20%	54%
Has inclusive design information been made more accessible?	79%	100%	67%	3%	0	23%
Would the tool be beneficial when designing?	100%	100%	62%	0	0	15%
Will you use ErgoCES when it becomes widely available?	100%	100%	64%	0	0	15%

The results show that while the quality of the information provided by ErgoCES was positive, the user interface had scope for improvement.

The majority of the participants also felt the tool had improved the accessibility of inclusive design information. 100% of the design students (both undergraduates and postgraduates) felt that the tool would be beneficial when designing, and they would use ErgoCES when it becomes available. 77% of the design practitioners also felt that the tool was beneficial and 79% would use ErgoCES when it becomes available.

The participants were also encouraged to provide additional feedback at the end of the questionnaire. Feedback from the professionals found that the examples of case studies were useful. One of the participants commented that:

"*Case studies offered examples of other projects and as a good starting point*".

At the same time, the professionals commented that they found ErgoCES to be useful at the early stages of the design process, commenting that:

"*It would help support initial prototyping / design as well as validate existing data collected. I think it would be an excellent tool*", and:

"*As a starting point for design, it might provide a good reference for early prototyping of products with which you could then compare with real life testing*."

In terms of visual interface, positive feedback was also received from the professionals commented that:

"*Visualisation of static single dimension data was fantastic: Much better than books*."

In addition, the students also liked the references provided in the ErgoCES, commenting that:

"*The Hand and arm data was related to the major project and the references are brilliant*".

Despite the general positive feedback from students and practitioners, it was found that the choice of certain visuals needed to be reconsidered. The participants suggested that some of the images that showed people could be better chosen to prevent a negative stereotype from being portrayed.

4 DISCUSSION

The development of ErgoCES has provided a more visual approach to the presentation of ergonomics data and has made it more accessible for designers. The tool has also incorporated useful and relevant information such as case studies in the 'Product Universe'.

The feedback from design students and professionals was generally positive, though the design students gave more positive feedback compared to the professionals. This might be because the design students were in need of general ergonomics information, as opposed to the professionals who

required more specific and job-related information. In terms of raising the awareness of inclusive design, the tool had a significant impact on design students, but had limited effect on professionals. This might be because most of the professionals who participated in the evaluation were already aware of inclusive design.

The key value of the ErgoCES lies in its visual interface. However, while adding images, bias was also introduced to the original data, for example, the definition of 'clearance' may be applicable to different scenarios, and the image of 'clearance' in Figure 4 only suggests a specific scenario. At the same time, it was a challenge for the authors to select suitable images that would be representative of people for a region. A suggestion was that it might be better to use photos that show groups of people as opposed to individual photographs.

5 CONCLUSION AND FUTURE WORK

ErgoCES translates ergonomics data into a more visual and relevant approach for designers. The "People Universe" database enables designers to quickly grasp the essence of the data. The "Product Universe" is valued by both design students and professional designers. The link between the "People Universe" and the "Product Universe" databases would be most useful and it would add value to develop specific design case studies which illustrate the application of ergonomics data.

Among the participants of the evaluation studies, 100% of the design students and 79% of the professionals indicated that they would use the tool when it becomes widely available.

Future work includes the improvement of the ErgoCES interface, refining the images and developing more product case studies with closer links to population data. It is also useful to tailor ErgoCES for different users, for example design students and professionals.

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