

Teaching Triangulation in Ergonomics

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Abstract. The Railway Risk and Safety Management MSc programme, offered by the Universities of Birmingham and York, includes a week long module ‘Practical Ergonomics for Railway Systems (PERS)’. Through this module, the course team seeks to impart knowledge about ergonomics and human factors and to develop in students a holistic understanding of the role and approaches of ergonomists. Students from Europe and overseas, both part and full-time, with a variety of experiences and from different cultures, engage in a module that is intentionally designed to balance theory of ergonomics with its application to practical problems. This paper, discusses the reasoning behind the module design and the purpose of the components included.

Keywords. Ergonomics, Risk, Teaching, Triangulation

1. Introduction

An MSc programme tailored to satisfy the needs of Britain’s railway industry was launched at the University of Sheffield in 1995, as a direct consequence of the 1993 sale of the national railway infrastructure to Railtrack plc and the parallel franchising of the passenger railway operations on the network. The MSc programme in Railway Systems Engineering or RSE, the first course of its kind, was highly successful, recruiting many students from around the globe rather than just the UK. The resulting need to strengthen the staffing of the programme prompted its move to The University of Birmingham in 2005, where it was integrated into the Birmingham Centre for Railway Research and Education, as the MSc programme in Railway Systems Engineering and Integration (RSEI).

At Birmingham, the programme team retained the proven structure involving eight week-long intensive modules, each covering an aspect of railway engineering, railway management or operations. From the first year at Sheffield, the MSc had also included an ergonomics module, which addresses both the design of physical systems and the human factors issues associated with working in the complex railway context and within railway hierarchies. Given the importance of people in the safe and efficient running of railways, this module was kept too, as a matter of course. To be immediately useful to the students, it combines ergonomics theory with a two-day workshop period, where they can apply their newly gained knowledge and knowhow to real-life problems, as will be discussed later.

For many of the engineering and technology focused students, the theory and practice of ergonomics feels markedly different to other modules with its hands on approach throughout the week and it is typically highly rated.

The cohorts of the programme at Birmingham grew quickly and so did the demands placed on it; the ergonomics module being attended by around 40 students. In particular, a number of significant and much worse than expected railway accidents had led to the realisation that the human element was still not considered adequately in railway systems design and operation. Happily, a major grant awarded by the Lloyd’s

Register Foundation in 2012, allowed the Universities of Birmingham and York to develop a new MSc programme in Railway Risk and Safety Management, to be based at The University of Birmingham, with a first intake in 2013. This resulted in a novel approach where the team at The University of Birmingham teaches the technical and operational railway focused elements of the programme while a team from the High Integrity Systems Engineering group at The University of York teaches the principles and practice of risk identification and risk management in product and process design.

It was evident from the start that this new programme would also need an ergonomics input. Following trials with a two day ergonomics element taught by engineers, the joint programme team decided to create a new week-long ergonomics module that would encourage the students to adopt a proper systems engineering approach to the solution of people related issues in railways. A major focus of the PERS module was to be on proper problem identification, encouraging students to avoid applying preconceived solutions before having understood the problem properly.

The new MSc module is again practice oriented, with an input on the theory of ergonomics at the start of the week, highlighting the foundation techniques for investigating and accommodating humans within systems. This is followed by significant experimental work where new knowledge can be applied almost immediately. Throughout the week a practical project is conducted by groups of 4-6 students.

The concept behind the design of the module evolved from that adopted for the MSc in RSEI ergonomics, which has a strong focus on task analysis. The new module is based on a development of this, the triangulation approach.

2. Why Triangulate?

The concept of Triangulation, involving the processes of Measuring, Watching and Asking, is illustrated in Figure 1. Rothbauer (2008) described the benefit of triangulation to be that *“the phenomena under study can be understood best when approached with a variety or a combination of research methods.”*

In endeavoring to teach robust ergonomics practice, the designers of the module have consistently emphasised that the discipline of ergonomics is about the successful integration of user characteristics, task design, and equipment and workplace factors. This has been reinforced by a focus on investigating issues from the corresponding perspectives, teaching the concepts and techniques shown in Table 1.

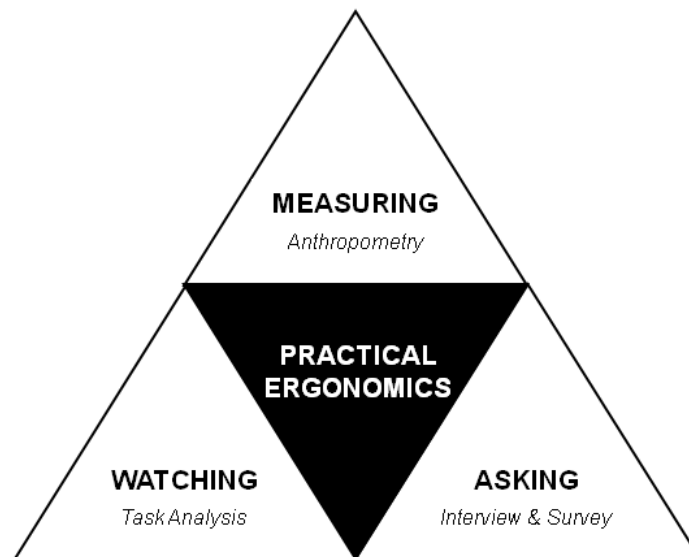


Figure 1: Teaching Model Adopted for PERS

Table 1: Concepts and Techniques Taught on PERS

User Characteristics	Task Design	Equipment/Workplace
Anthropometry Psychological Factors Accessibility/Inclusivity	Task Analysis Musculoskeletal Risk	Fitness for Purpose Fitting Trials User Trials

Triangulation is encouraged to convey several important messages to the students:

- That the inevitable subjective aspects of ergonomics are very important and should not be disregarded. Triangulation makes sense of opinions and perceptions and helps to sift the ‘off the wall’ elements from the valid common factors;
- Comparing objective and subjective information and data yields evidence which is more convincing than a single source, especially if the ergonomics literature forms an additional perspective;
- The very process of triangulation causes the investigation to slow down. This can, at first, seem frustrating and unnecessary for students who seem to have an ever increasing tendency to simply search the internet for existing solutions which seem ‘close enough’ according to the often impressive images or sales pitch. Drawing students back to first principles enables them to properly consider the issues instead of simply jumping to solutions. Experience suggests that the adoption of existing solutions often leads to abandonment as users later reject approaches that do not fully satisfy their requirements;
- By considering the different aspects of an ergonomics investigation it is possible to understand more fully both the functional and acceptable features of a solution. This gives greater confidence for investment and implementation.

3. Module Design

To inspire the students to consider the deployment of ergonomics beyond the end of the designated ergonomics week, it has become successful practice on the ergonomics modules to include a very strong practical element (Hitchcock and Schmid, 2015).

For the new version of the module, therefore, a week-long assignment was devised to provide an opportunity each afternoon to utilise the morning's taught material as part of the investigation of a real world ergonomics issue of the railway system in the West Midlands area. The components are described in Table 2.

Table 2: Components of the 'Practical Ergonomics for Railway Systems' Module

Component	Justification
Introduction to the Module and to Ergonomics	This will usually be the first time the students have encountered such a hands-on module, and for the majority ergonomics will mean little more than the historical 'knobs, dials and seats' view.
Risk Factors and Triangulation	The focus of the course is the management of risk and safety, and the adoption of a triangulated approach provides a strong evidence base in a sector arguably does not have a strong record of good ergonomics.
Watching	The first element of observation from direct to recorded is used to teach task analysis which is subsequently practiced in the class room before doing likewise on-site for part 1 of the assignment.
The Human Factor	This session builds on the introduction lecture, looking at physical ergonomics and the role and use of anthropometry, with particular emphasis on human variability.
Literature	The use of literature to support all aspects of the triangulation is discussed to highlight the availability, scope, limitations and the need to adopt a critical review and consider context.
Measuring	Building on the anthropometry teaching, the accommodation of people in various rail settings is considered in preparation for the on-site assessment of user fit in part 2 of the assignment.
Asking	A session looking at interview and survey techniques, questionnaire design and, most importantly, how to engage users to yield the information pertinent to the triangulation.
Survey Preparation	This session is a practical one during which the students consider all of the earlier work in order to produce a questionnaire for use on-site as the third part of the triangulation assignment.
Case Studies	Example case studies are presented that provide actual examples of the impact of both the inclusion and exclusion of the triangulated approach to address railway ergonomics issues.
Risks to Controls	This session uses the RSSB 'MSD risk Assessment for Train drivers (MAT) tool' – one of the few rail-specific ergonomics tools, to demonstrate triangulated investigation and improvement.
Evaluating Solutions	This practical part 4 of the assignment is intended to interpret the triangulated data and information to develop and trial a potential solution to the problem investigated.

4. What the Students Say

Purely to illustrate the impact on their thinking about, and approach to ergonomics, the following comments made by students following the module regarding their

experiences while applying the triangulation approach include the following:

- *“...a structured approach enables the identification of the problem and increases the likelihood of the complete set of requirements being captured and understood.”*
- *“...trials yield pragmatic insights and (that) good design must be an iterative process involving users.”*
- *“...it was apparent that the psychosocial factors needed even more careful consideration than the physical.”*
- *“...while a great deal of effort is put into what standards mandate, which should reflect the end user requirements, the whole journey experience is rarely considered.”*

5. Discussion and Conclusion

In railway systems development, as in many other engineering led activities, ergonomic design efforts have tended to be limited to the enhancement of passenger and staff comfort, often at a late stage in the process, either as an afterthought or as a reaction to user complaints. Even in situations where the consideration of ergonomics issues was part of the agenda from the start of a project, approaches rarely went beyond the consultation of design manuals and a few user trials with mock-ups. The ‘ergonomics investigation’ that was undertaken in the early 1990s during the design and selection process for the optimal driver’s desk for the European Train Control System provides a good example of this state of affairs: Although no formal task analysis had been undertaken at the start of the project, the partners created three different driving cab mock-ups, each based on best practice in one of the European client countries. The cabs toured Europe on the back of a lorry and a significant number of train drivers were asked to sit in the cab and to ‘drive’ a train using the human machine interfaces provided. One of the mock-ups was of a very high production standard, with a comfortable seat and a layout that had been designed taking into account anthropometry data. Not surprisingly, this was the design chosen by the drivers, effectively by counting and combining the votes from each venue.

The team in charge of the PERS module has adopted a very different philosophy by asking students to diligently explore the influential factors and to work with intended users to establish robust requirements for the solution before starting the design process. A project undertaken by one of the MSc groups at Birmingham in 2012 is a good example of this approach: During a visit to New Street Station, the group uncovered regular congestion at the foot of the stairs to the platforms, in a location where escalators were due to be installed. By interviewing a range of passengers and staff, they learnt that people were confused about the side of the platform on which their train would appear. Although the task was perceived to be somewhat basic, the team conducted a formal task analysis and anthropometry study.

The members then produced an example of highly effective signage (Figure 2 below) that they tested for visibility and clarity, in a very similar setting to the real situation. One of the members went on to complete an ergonomics based project for their MSc dissertation.



Figure 2 Signage for New Street Station, developed as Part of a Group Project

In this paper, we have attempted to show that triangulation is an effective tool to teach ergonomics to engineers and engineering managers, not least because it has clear similarities with the approaches used in systems engineering with which they have a degree of familiarity.

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