THE DERIVATIVE MODEL APPROACH TO IMPROVING ICT USABILITY

Ritch Macefield
Shannon-Weaver Ltd, 19 Cornovian Close, Perton, Wolverhampton, WV6 7NU, U.K.

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Abstract: This paper describes the novel “Derivative Model approach” to improving the usability of ICT systems, along with a formal usability study to prove the concept of this approach. This approach is grounded in, and makes contemporary, successful research carried out in the 1980s that applied thinking around conceptual and mental models to the field of Human Computer Interaction (HCI). The study found initial evidence that this approach might significantly improve usability in terms of task effectiveness but not in terms of task efficiency. The study also found evidence that the benefits of the approach might improve along with task complexity.

1 INTRODUCTION

It is generally accepted that we have made considerable progress over the last decade in improving ICT usability. For example, over this period, the mean task completion rates for the WWW based systems that pervade today in the area of 78% (e.g., Nielsen (2010). However, with a 22% task failure there remains significant room for improvement.

It seemed to this author that much of the focus for seeking progress in this area can be categorised into two main areas. The first is by the continued application of established interface design guidelines such as those originated in Nielsen (1991). In other words, we attempt to improve usability by making the interface *intrinsically* more usability. The second is by providing, or improving, one or more of the following utilities: on-line help facilities, free text search facilities and site maps (e.g., Nielsen, 1991; 2002; 2005). In other words, we attempt to improve usability by *augmenting* the interface with well-established user support utilities.

However, there is another approach to progression in this problem area that is qualitatively different to the two cited above – this is what the author terms the *Derivative Model approach.* The fundamental idea with this approach is that the usability of a modern ICT system, such as a WWW based system, might be improved if we provide the user with a conceptual model of the system that is derived *directly* from the *conceptual model* that was used to design the system. The rationale being that this provision might improve the accuracy of a user’s *mental model* of the system and that, in keeping with the ideas set out in Norman (1983), this leads to an improvement in usability.

2 CONCEPTUAL MODELS AND MENTAL MODELS

To understand the derivative model approach it is first necessary to establish some founding principles related to conceptual and mental models and, in particular, how these ideas relate to ICT systems:

- A *model* of an artefact is some form of *abstraction* that lacks the full detail or accuracy present within the artefact itself; therefore, in producing a model, some properties of the artefact are ignored, simplified or distorted (Macefield, 2005).
- A *conceptual model* implies an abstraction concerned only with the key, or fundamental, properties of an artefact. Such models are often used to explain the basic principles of how something works (Macefield, 2005).
- Most cognitive scientists agree that our perception of the world is constructed from

Macefield R..
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mental models. We use these models to explain our world, to anticipate events, and to reason. This insight originated with Plato, was first formalised by Craik (1943) and has been widely applied to HCI thinking (e.g., Norman, 1983; Johnson-Laird et al., 1983; Macefield, 2005).

- Norman (1983) crucially distinguished between conceptual models; which exist in a concrete form, e.g., a diagram and mental models; which exist only in someone's *mind*. Norman (1983) further explained how a conceptual model can be provided as an explanation of an ICT system which the user will then *interpret* into a mental model.
- Norman (1983) hypothesised that without being provided with a conceptual model, users will *always* develop a mental model to explain the behaviour of an ICT system, but argued that, in most cases, this model will be (highly) inaccurate. Empirical research carried out by Mayer & Bayman (1981) and Bayman & Mayer (1983) supported this argument.
- Norman (1983) argued that, even if provided with a conceptual model the resulting mental model formed by the user will often differ, and the two models are *never* likely to overlap completely. Research carried out by Khella (2002) supported this argument.

3 THE MODEL APPROACH

Using the principles set out in Section 2, researchers in the 1980s hypothesised that ICT usability generally improves along with the accuracy of a user's mental model. So, whilst accepting the arguments in Norman (1983) that no mental and conceptual models are ever likely to overlap completely, they set out to improve the accuracy of users' mental models by providing users with conceptual models of the ICT systems with which they were interacting.

In some research initiatives, these models were provided in the form of a *metaphor*, e.g., Borgman (1986) used a card index metaphor to explain how a library system worked, whilst other research used a *developer eye* model whereby users were provided with, e.g., the entity-relationship diagrams used to design the system. These are both examples of what the author terms the *model approach* to improving usability.

The principal empirical studies that explored the model approach were: Mayer & Bayman (1981), Foss et al. (1982), Bayman & Mayer (1983), Kieras & Bovair (1984), Borgman (1986) and Frese & Albrecht (1988). These studies produced three finding that are key to this paper:

- All of the studies found that the model approach can lead to general improvements in usability that are statistically significant.
- Four of the studies found that the effectiveness of the approach increased along with *tasks complexity*.
- The study by Kieras & Bovair (1984) found that it was particularly important that the conceptual model includes a "*system topology*"; which defines the key components of the system and how these components relate to each other. They also argued that the importance of providing a system topology increase along with *task complexity*.

Although these findings were both interesting and encouraging, work on the model approach diminished at the end of the 1980s.

The main reason for this seems to be that, despite many valiant attempts, researchers failed to develop any *generalised theory of user's mental models* (e.g., Borgman, 1986; Carroll & Olson, 1988; Sasse, 1991).

This failure was critical because it remained impossible to directly study a user's mental model and, consequently, impossible to prove, or even explore, any *causation mechanism* that would explain how providing a (particular) conceptual model might have (beneficially) influenced a user's mental model. Put more simply: whilst we could quite easily demonstrate that providing users with (better) conceptual models can improve ICT usability, these researchers demonstrated that we are not able to explain *how* this happens, or even demonstrate that this involves a user's mental model at all.

Of course, all researchers working in this area would want to be able to explain any causation mechanisms that led to their results. Therefore, it is little surprise that many researchers have (perhaps sometimes naively) been seduced down this path. However, the reality is that we are presently limited to *conjecture* to explain any causation mechanisms with the model approach.

Despite this limitation, this author believes that the model approach retains merit: just because we might not understand, or be able to prove, *how* this approach works, the fact that is *does* seem to work makes it well worthy of attention.

4 THE DERIVATIVE MODEL APPROACH

Given the author’s belief in the fundamental merits of the model approach, a research initiative was established that set out to build on previous work in this area by both adding some novel thinking and making the approach more contemporary; in particular, making it applicable to the WWW based systems that are so pervasive today.

The first step in this initiative was to addresses two key questions:

1. What might be the best *type* of conceptual model to present to users as an explanation of an ICT system?
2. Through what *medium* should this model be communicated to users?

4.1 Type of Conceptual Model

In Section 3 it was explained that some of the empirical studies that explored the model approach in the 1980s used a *metaphor* as the conceptual model.

The use of metaphors was rejected outright in this research initiative. This was because ICT systems benefit from concepts that have little or no equivalency in the physical world. This can make them limited, or even misleading, in their ability to describe an ICT system. For example, with the windows metaphor, it is easy to understand how a user may (quite reasonably) conclude that an ICT window cannot be resized because that is how things work with physical windows.

Others studies described in Section 3 used a *developer eye* model whereby users were provided with models used to design the system. This approach is superior to using metaphors in that is can *completely* and *accurately* explain a system’s conceptual model. However, these models have the serious drawback that they (inevitably) involve esoteric notations and formalism that we can not expect the typical user to understand. For example, consider the Unified Modelling Language (UML) Class Collaboration Diagram in Figure 1. As explained by e.g., Hunt (2000), UML Class Collaboration Diagram are often the tool of choice for technical architects designing modern ICT systems. However, it is easy to understand how the typical user would be overwhelmed, frustrated or confused if presented with such a diagram as an explanation of a system.

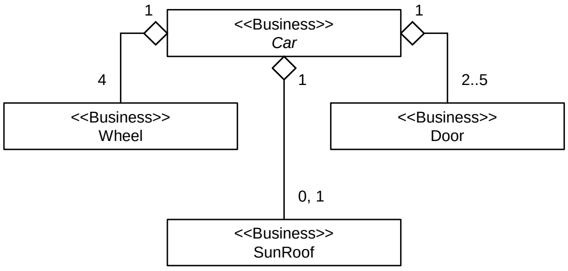


Figure 1: Example of a UML Class Collaboration Diagram.

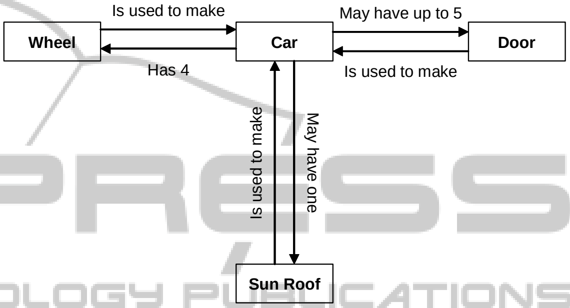


Figure 2: Example UCCD Diagram derived from the UML Class Collaboration Diagram shown in Figure 1.

To address this drawback of developer eye models, the author sought a means by which these (UML) Class Collaboration Diagrams could easily be *derived* into a form that typical users might understand, but without loosing any information or accuracy contained within the model. It is this feature of the author’s work that gave rise to the term “derivative” within the derivative model approach.

Meeting this challenge resulted in the idea of a *User-centred Class Collaboration Diagram (UCCD)*, and an example of the UCCD which is derived from the UML Class Collaboration Diagram shown in Figure 1 can be seen in Figure 2.

As can be seen from figures 1 &2, the method for deriving a UML Class Collaboration Diagram into a UCCD is simply that:

- the class package names (in stereotypes the class title) are removed,
- the class names are made bold,
- the text size is increased,
- each relationship is shown using two unidirectional arrows,
- any multiplicity of the class collaborations are explained using short phrases centred along the association arrows,
- concatenated words are separated e.g., the class title “SunRoof” is changed to “Sun Roof”.

In keeping with the advice in Kieras & Bovair (1984), it can also be seen from Figures 1 & 2 that a key feature of UCCDs is their ability to clearly communicate the *system topology*.

The rationale for the UCCD shares some similarity with “Object, View and Interaction Design” (OVID) developed by Robert et al. (1998) in that both UCCDs and OVID attempt to make modelling ICT systems using the UML more relevant to the discipline of HCI.

However, UCCDs and OVID differ greatly in two important ways. Firstly, a UCCD is simply a *type* of diagram for *representing* the conceptual model of an ICT system, whereas OVID is a whole *method* for actually designing ICT systems. Secondly, in keeping with their primary purpose, the diagrams used within OVID retain a high degree of formalism and, in this author’s opinion, remain esoteric to the point of making them unsuitable for presentation to the typical user as an explanation of an ICT system. In summary, OVID is (and was designed to be) a device targeted at ICT system *designers*, whereas UCCDs are a device targeted at ICT system *users*.

4.2 Communicating the Conceptual Model

Within the empirical studies cited Section 3 the conceptual model was presented to users by either face-to-face teaching or some form of hard copy user manual. These communication media were typical of ICT usage in the 1980s when these studies were conducted; however they are clearly inappropriate to e.g., the WWW based systems that pervade today.

Given this, it was decided that the Derivative Model approach would communicate the conceptual model to users through *self-explanatory video presentations* that used voice and screen capture technology to explain the UCCDs in a ‘rich’ way.

The voice input for these presentations was simply to read out the relationships on the UCCD e.g., “A *wheel* is used to make a *car*”; with emphasis being placed on the class name. The idea here being that this makes the information more attractive and easier to cognise for the user.

Importantly, it was anticipated that this communication medium would have considerably familiarity to modern ICT users since it is now widely used to explain key features of ICT systems, via online services such as YouTube and Vimeo. However, some (arguably) novel thinking here was that, rather than these video presentations being provided externally to the system (through third party services), the author envisaged them being *embedded*, as a key featured, within the system itself; perhaps as part of the system’s help facility.

Having developed the Derivative Model approach in theoretical terms, the next stage in this research initiative was to conduct a *formal usability study* to act as an initial ‘proof of concept’ for the approach.

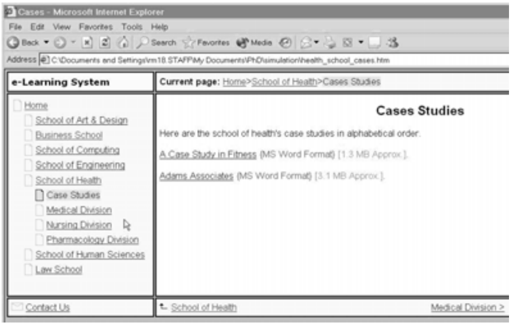
5 INITIAL PROOF OF CONCEPT USABILITY STUDY

The proof of concept usability study for the Derivative Model approach was specifically designed to have three key features as follows:

- In keeping with the overall goals for this research initiative, the study used a modern WWW based ICT system as the test artefact.
- Some of the empirical studies carried out in the 1980s (cited in Section 3) compared the model approach with other approaches to improving usability e.g., providing conventional training manuals and various training methods. Other studies compared the effectiveness of one type of conceptual model to another. Another type of study simply compared usability *with* and *without* the provision of a conceptual model, so that one of two test groups simply acted as a *neutral control*. The proof of concept usability study for the Derivative Model approach was of this *latter* type. This is because a primary aim of this study was to identify if the Derivative Model approach might *add* sufficient value to a modern ICT system such that system vendors might consider the extra cost and time involved in providing a conceptual model to be justified.
- In keeping with the findings of the empirical studies cited in Section 3, the study incorporated features to determine if any benefits of the Derivative Model approach might increase along with *task complexity*.

5.1 Test Artefact

In keeping with the overall research aims here, the test artefact was a WWW based prototype e-Learning developed using HyperText Mark-up Language and Cascading Style Sheets which from hereon will be referred to as “the prototype”.



C:\Documents and Settings\rm18.STAFF\My Documents\PhD\simulation\health_school_cases.htm

e-Learning System

Current page: Home>School of Health>Cases Studies

- Home
  - School of Art & Design
  - Business School
  - School of Computing
  - School of Engineering
  - School of Health
    - Case Studies
    - Medical Division
    - Nursing Division
    - Pharmacology Division
  - School of Human Sciences
  - Law School

Cases Studies

Here are the school of health's case studies in alphabetical order.

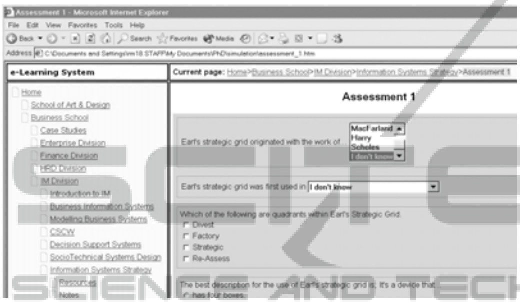
A Case Study in Fitness (MS Word Format) [1.3 MB Approx.].

Adams Associates (MS Word Format) [3.1 MB Approx.].

Contact Us

School of Health Medical Division >

Figure 3: Example screenshot from prototype.



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e-Learning System

Current page: Home>Business School>IM Division>Information Systems Strategy>Assessment 1

- Home
  - School of Art & Design
  - Business School
    - Case Studies
    - Enterprise Division
    - Finance Division
    - HRD Division
    - IM Division
      - Introduction to IM
      - Business Information Systems
      - Modelling Business Systems
      - CSCW
      - Decision Support Systems
      - SocioTechnical Systems Design
      - Information Systems Strategy
        - Resources
        - Notes

Assessment 1

Earl's strategic grid originated with the work of... MacFarland / Harry / Scholes / I don't know

Earl's strategic grid was first used in: I don't know

Which of the following are quadrants within Earl's Strategic Grid.
☐ Divest
☐ Factory
☐ Strategic
☐ Re-Assess

The best description for the use of Earl's strategic grid is; It's a device that...
○ has four boxes.

Figure 4: Example screenshot from prototype.

As illustrated in Figures 3 & 4, the prototype had a hierarchal structure whereby a fictional university was comprised of seven schools e.g., the "Business School". Each school had an area for case studies and a number of divisions e.g., the "Information Management Division". Each division has a number of modules (courses) e.g., "Information Systems Strategy" and each module had a number of resources e.g., notes and assessments.

5.2 Conceptual Model for Test Artefact

Figure 5 shows the UML Class Collaboration Diagram used to design the Prototype, and Figure 6 shows the UCCD that was derived for the prototype using the method set out in Section D.1.

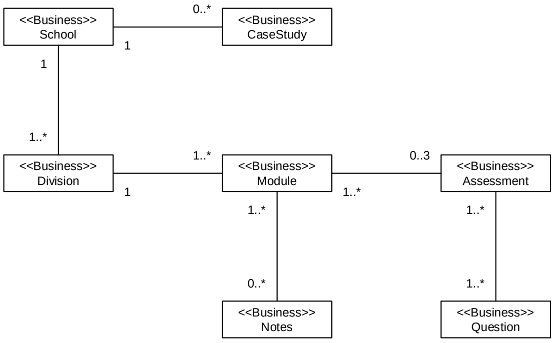

Figure 5: UML Class Collaboration Diagram for Prototype.

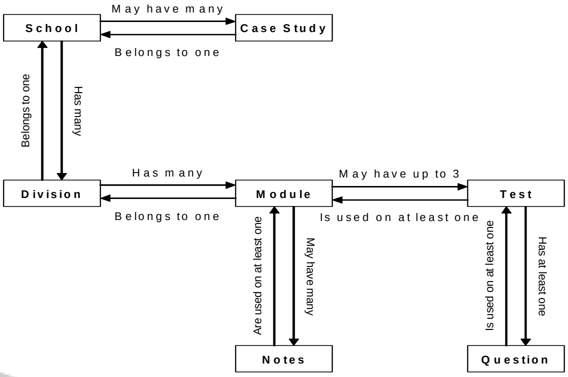

Figure 6: UCCD for Prototype.

In keeping with the ideas set out in Section 4.2, a third party, who had been briefed on the Derivative Model approach, used the UCCD illustrated in Figure 6 to produce the necessary self-explanatory video presentation using standard screen and voice recording software.

The recording, editing and final run time for the presentation was as follows:

Recording Time (mins.)	**8**
Editing Time (mins.)	**4**
Run Time (mins.)	**1**

From this data it can reasonably be concluded that production of the self-explanatory video presentations was not particularly time consuming. The process was also not particularly onerous. Similarly, the total run-time was very short, implying that users viewing the presentation would seem unlikely to find using them particularly onerous.

5.3 Study Groups

There were three important features of the study groups:

- In keeping with the study's aim that it should investigate any value that might be *added* by the Derivative Model approach, the study had an *asymmetric design* involving two groups of participants. The control group (G1) used the prototype without viewing the self-explanatory presentations. By contrast, the experimental group (G2) used the prototype shortly after viewing the presentations.
- As the study was a proof of concept the author was seeking *quantitative results* that were *statistically significant*. Therefore, using the advice provided by Macefield (2009), the study group size was set to *12 participants*, making

Table 1: Overall results for proof of concept usability study.

Metric	G1	G2	Hypothesis	Difference (pValue)
Efficiency (mean time, secs)	395	335	G1>G2	0.103
Satisfaction with efficiency (Median)	6	6.5	G1<G2	0.364
Effectiveness (Mean failures)	0.52	0.31	G1>G2	**0.009**
Satisfaction with effectiveness (Median)	5	6	G1<G2	**0.017**

Table 2: Results for measured tasks four and eight.

Task	Metric	G1	G2	Hypothesis	Difference (pValue)	G1 & G2
4	Efficiency (mean time, secs)	53	43	G1>G2	0.36	48
4	Effectiveness (Mean failures)	0.46	0.25	G1>G2	0.24	0.35
8	Efficiency (mean time, secs)	136	121	G1>G2	0.25	129
8	Effectiveness (Mean failures)	0.77	0.16	G1>G2	**0.004**	0.47

24 participants for the study as a whole.

- To help increase the validity of the study, all participants were recruited from a cohort of 1st year university students (in the UK) and randomly assigned to one of the two study groups. This was done whilst ensuring that there was a broadly equal distribution of age and gender across the groups. Similarly, participants all had: English as their first language, no disabilities in relation to ICT, and were examined to ensure they had the requisite baseline PC and internet skills.

5.4 Facilitation and Recording

The study consisted of 8 small tasks that were indicative of using a modern e-Learning system e.g. navigating to particular areas of the prototype, locating a particular case study and completing a simple on-line test. Four of these tasks were defined as "measured tasks". These were tasks to which metrics were applied and which were specifically designed to detect any affect of the Derivative Model approach. The other four tasks were there to provide a 'warm up' for participants and form a coherent 'link' between the measured tasks, so that the tasks 'flowed' better for the participants i.e., made the test a little more realistic.

In keeping with the study's design features set out at the beginning of this section, measured tasks four and eight were specifically included to investigate whether or not any benefits of the Derivative Model approach increased along with *task complexity*. These tasks were deliberately made similar in that they both required participants to navigate to a particular case study within the prototype by clicking links. However, task *eight* was designed to be significantly more complex than task four in three ways:

- Completion of task four required a minimum of two mouse clicks, whilst task eight required three clicks.
- With task *four*, participants were provided with the exact name of the case study to locate. By contrast, the instruction to participants was vaguer with task *eight* whereby participants were simply asked to locate a case study "related to fitness".
- The breadth of the navigation across the prototype's structure was greatly increased with task *eight*. Unlike task four, completion of task eight required participants to navigate outside of the "Businesses School", where they were located for all previous tasks in the test, and into the "School of Health" i.e. it involved navigating through a higher level in the prototype's hierarchy.

5.5 Metrics

The primary metrics used in the study assessed usability in terms of how it is defined in ISO 9241-11:1998 – *effectiveness*, *efficiency* and *satisfaction* as follows:

- Efficiency data was collected by recording the time taken to complete each task.
- Effectiveness was recorded using a binary value if a participant failed a task. There were three failure modes: The first was the participant making more two errors with the task, which were obviously of a fundamental nature e.g., looking for an on-line test in a "case studies" section of the prototype. The second was the participant exceeding the maximum time allowed for the task; which was set very

conservatively using data gained from pilot testing. The final failure mode was the participant giving up on the task.

- Satisfaction data was collected post-test, using two questions from the ASQ questionnaire developed by Lewis (1991). The first question assessed *satisfaction with effectiveness*. The second question assessed *satisfaction with efficiency*.

5.6 Experimental Effects and Study Critique

The study included the following features designed to eliminate or minimise any confounding experimental effects and maximise objectivity:

- The prototype was a bespoke (custom) artefact produce specifically for this study. Therefore none of the study participants could already be familiar with any of its functionality.
- The prototype conformed to 28 well established usability guidelines. This was to guard against generic usability problems becoming an effector in the study e.g. making some parts of the prototype difficult (or even impossible) to use by *any* participant.
- The study relied exclusively on *quantitative data* measured post-test from the test recordings and questionnaires. There was no interpretation involved in the metrics and the study deliberately excluded any verbal protocols.
- The moderator's verbalizations were very carefully scripted in considerable detail. This included definition of all moderator inputs and pre-emptive responses to participant's request for assistance. This script was applied rigorously and consistently to all participants in order to minimise variation in task moderation.
- A reasonable set of failure criteria for the effectiveness metrics was clearly defined in advance of the study and applied rigorously and consistently to all participants by the moderator.
- No performance feedback was provided to participants by the moderator at any stage. This was to protection against the "Parson's interpretation" of the Hawthorne effect explained in Macefield (2007).

As explained in section 4.2, it was envisaged that the self-explanatory presentations, inherent within the Derivative Model approach, would be embedded in some way into the ICT systems they explained (possibly within a wider help facility). This raises issues as to how users might be made aware of the existence of these presentation and under what circumstances they might be accessed by users. Whilst these are important questions, they were scoped out of this study and left as a matter for further research. This was to ensure that these issues did not become confounding factors in addressing the core objectives for this stage of the research initiative i.e., a proof of concept for the Derivative Model approach.

Given this, the conceptual model was explicitly presented *simultaneously* to all participants in G2 by showing them the self-explanatory presentation within in a class room setting. In keeping with the run time for the presentation (stated in Section 5.2) these sessions lasted approximately one minute.

6 RESULTS AND DISCUSSION

Table 1 shows the overall results for the study. The effectiveness data was categorical and pValues for this metric were determined using the Fisher Exact Test. Values for efficiency data (interval) and satisfaction data (ordinal) were determined using Mann-Whitney U-test.

From Table 1 it can be seen that there was no significant difference between G1 and G2 in either efficiency or satisfaction with efficiency. However, there were significant differences in both *effectiveness* and *satisfaction with effectiveness* (revise Section 5.6 for the definitions and metrics for these satisfaction metrics).

Closer analysis of the results data revealed that the vast majority of this difference between G1 and G2, in terms of overall effectiveness metric, was due to a large difference in performance across G1 and G2 for measured task *eight*. Indeed, the *only* statistically significant difference between G1 and G2 for the effectiveness metric occurred with this task.

This difference can be seen in Table 2 and was interesting because, as set out in Section 5.4, the primary reason for including task eight was to form a comparison with task *four*, in order to help determine if any benefits of the Derivative Model approach increased along with *task complexity.*

Given this, the next step in the results analysis was to determine if the test participants, *as a whole*, found task eight (significantly) more complex than task four as intended in the study's design.

From the data in Table 2, it can be seen that, *across all participants*, there was a very large difference in the mean task completion time across these tasks: *48 seconds* for task *four* and *129 seconds* for task *eight* (*p=0.0005*). From this, it seems reasonable to conclude that participants generally found task eight significantly more challenging than task four. In turn, it seems reasonable to argue that, in keeping with the study's design, this was due to the additional complexity designed into task eight.

The next step in the analysis was to investigate why there was no significant difference in task *efficiency* across G1 and G2 with task eight, whilst there was a significant difference in task *effectiveness*. To do this the raw video data generated from the study was reviewed in detail.

As stated in Section 5.4, task eight asked participants to navigate to a case study related to "fitness" within the prototype. Completion of task seven left participants located within the "Cases Studies" page of the "Business School" section of the prototype. The link to the fitness case study was (quite deliberately) not placed on this page; rather, it was placed within the "Cases Studies" page of the "School of Health" section. Therefore, completion of this task first required participants to navigate to the "School of Health" section using the menu to the left of the page.

Review of the video data revealed that, independent of their group, the vast majority of participants engaged with task eight initially spent a long time simply scrolling up and down the "Cases Studies" page within the "Business School" section (i.e., where they were located at the end of task seven) before making *any* mouse clicks (or performing any other type of action). It seemed that most participants were searching for the correct link within this page and were very reluctant to navigate away. Indeed, across all participants, the mean time taken to make the first mouse click accounted for *92%* of the total mean time to complete, or fail with, this task.

Of further importance, this review found that those participants whose first mouse click was correct (clicking on the "School of Heath" link in the menu) would *always* go on to complete the task. Further, they did this without *any* errors or making *any* requests for assistance from the facilitator.

To summarise here, independent of group, it is easy to argue that the key to effectiveness with task eight was locating the first correct link, and that most participants spent a long time looking for this link in the *wrong* area of the prototype.

Other than this, the pattern of interaction with task eight was *quite different* across G1 and G2. After the initial search of the "Cases Studies" page for the "Business School", the majority of participants in G1 either gave up on the task, made multiple errors by clicking links that were (quite obviously) wrong and/or made multiple requests for assistance to the moderator; all of which triggered a failure condition. By contrast, the majority of participants in G2 eventually elected to widen the scope of their search for the correct link, resulting in them quickly completing the task.

Based on these findings, it seems easy to conclude that participants in G2 benefitted from the Derivative Model approach in the case of task eight. This conclusion is consistent with the findings of most of the empirical studies cited in Section 3, that the usability benefit of providing a conceptual model to users increase along with task complexity.

As explained in section 3, our lack of a general theory of users' mental models means that exploration, or proof, of any causation mechanism that might explain how these benefits arose in this study is presently beyond us. Therefore, this aspect of the study must be a matter for conjecture.

One such conjecture is that these benefits are related to *functional fixity*, sometimes known as "functional fixedness". This phenomenon is often explained in terms of a fable:

A man knows that he has dropped his wallet *somewhere* along the street between his home and the neighbour he is visiting. It's night and the street is completely dark apart from a small area illuminated by a security light in a shop window. The man searches for his wallet for a long time within this area but without success; distraught, he stands there motionless. A stranger approaches and enquires as to the man's problem; she then asks why the man has not looked anywhere else in the street – the man replies "because this is the only place where I can see".

Put more formally, functional fixity occurs when we get stuck with problems because we *artificially* scope down our 'problem space' – hunting for a solution in a space that is too small (see e.g., Dominowski & Dallob, 1995).

This phenomenon relates well to ideas of mental and conceptual models within the context of usability, because functional fixity can occur when a user's mental model is smaller in scope than the conceptual model of the ICT system with which they are interacting. Based on this, it is easy to conjecture that, independent of group, the participants in this study experienced a *functional fixity 'trap'* with task eight whereby they got stuck trying to find the necessary link within the wrong page and were reluctant to *widen the scope of their search*. However, participants in G2 were far more likely to ultimately escape this trap due to the better *mental model* they had developed as a result of the conceptual model provided to them within the Derivative Model approach - knowledge that may well have been outside their consciousness.

7 CONCLUSIONS AND FURTHER RESEARCH

Conventional wisdom in user interface design is that conceptual (structural) information, such as that presented to the experimental group (G2) in this study, is in the domain only of ICT *developers*, not ICT *users*. Indeed, some might argue that a very rationale of good user interface design is to isolate users from such information. However, this research initiative has made contemporary an alternative perspective on improving ICT usability, that originated in the 1980s, whereby we seek to leverage users' mental modelling capability specifically through the provision of such information.

The proof of concept study within this initiative was small in scope and leaves open many areas for conjecture and further research. Key amongst these are: whether the approach can scale to real contemporary pervasive ICT systems and the tasks that these systems involve, how (practically) the conceptual information is best communicated to users, and whether or not users would (want to) make use of such information and in what circumstances.

However, the study has provided evidence that this approach may be a viable means of improving task *effectiveness* with such systems, particularly as task *complexity* increases. Therefore, this author argues that the Derivative Model approach is worthy of further research, within the wider context of this alternative perspective on progressing ICT usability.

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