Exploring frameworks for mixing DES and SD in theory and in practice

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Executive summary

1. Commonality/overlap of the methods

2. Framework of mixed method designs: categorising mixed methods projects

3. Mixing in practice

4. Practical challenges and value of mixing methods
Comparison of DES & SD (1)

<table>
<thead>
<tr>
<th>Philosophy</th>
<th>Paradigm</th>
<th>Methodology</th>
<th>Method</th>
<th>Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>Representation</td>
<td>Continuous</td>
<td></td>
<td></td>
<td>Discrete</td>
</tr>
<tr>
<td>Feedback (Explicit)</td>
<td></td>
<td>Feedback</td>
<td></td>
<td>No Feedback</td>
</tr>
<tr>
<td>Importance of stochastics</td>
<td>Low</td>
<td></td>
<td></td>
<td>High</td>
</tr>
<tr>
<td>Data dependency</td>
<td>Judgemental</td>
<td>Informational</td>
<td></td>
<td>Tangible</td>
</tr>
</tbody>
</table>

Requires good quantitative data
Comparison of DES & SD

**Goal / Aim**
- Develop understanding

**Process view**
- Dynamic complexity
- Detail complexity

**Problem scope**
- Policy
- Strategic
- Operational
- Logistical

**System**
- Boundary
  - Broad
  - Narrow

**System detail**
- Informational
  - Physical
- Holistic
  - Analytic
Selection of a project methodology

Appreciation of mixed method designs and published projects

(Lorenz & Jost, 2006)
Terminology

• Ambiguous terminology can muddy the approach taken

• ‘Hybrid’ may overemphasise the links drawn between the models

• ‘both methods’ may underemphasise
## Terminology

<table>
<thead>
<tr>
<th>Description of mix</th>
<th>Paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Both</td>
<td>Dierks, Dulac &amp; Leveson (2008), Martin &amp; Raffo (2000)</td>
</tr>
<tr>
<td>Composite</td>
<td>Brailsford, Desai &amp; Viana (2010), Viana et al. (2014)</td>
</tr>
<tr>
<td>Integrate &amp; Synchronise</td>
<td>Helal et al. (2007)</td>
</tr>
<tr>
<td>Integrated</td>
<td>Brailsford, Churilov &amp; Liew (2003), Reiner (2005)</td>
</tr>
<tr>
<td>Inclusion / addition</td>
<td>Phelps, Parsons &amp; Siprelle (2002) – referred to by brand name: Simulation Dynamics</td>
</tr>
<tr>
<td>Unclear – DES then SD</td>
<td>Brailsford et al. (2004)</td>
</tr>
<tr>
<td>Unclear – SD for DES</td>
<td>An &amp; Jeng (2005)</td>
</tr>
<tr>
<td>Unclear – SD in DES</td>
<td>Fioroni et al. (2007)</td>
</tr>
<tr>
<td>Unclear</td>
<td>Su &amp; Jin (2008)</td>
</tr>
</tbody>
</table>
Mixed method designs

- Isolationism
  - Methodology
  - Technique

- Parallel
  - Allows Comparison

- Interaction

- Sequential

- Enrichment

- Integration
  - New
The Beatson Project: Introduction

• Working with the Beatson

• Why Radiotherapy?
  – Complex, multistage process
  – Interrelated stages with feedback

• Overview
  – The aim was to apply the developed modelling methodology to pertinent issues within the radiotherapy centre
  – Issues are explored at both the strategic and the operational level ...
  – ...to shed light on the balance to be struck between what is hoped to be achieved, and what can realistically be implemented
Problem Definition

- Efficiency of treatment
- More complex treatment delivery
- Aspiring for excellence
- Capacity of the system
- Ensure full hospital service available to all
- Aspiring for equality
- Required treatment machine slot length
- Required Time to Image
- Required Time to complete plans
- Ability to meet KPIs
- Changes in treatment regime
- More complex imaging
- More complex verification
- More complex treatment planning
- Rationing of complexity
- Pressure to meet KPIs
- Research reputation of the department
- Experienced workforce
- Aspiring for excellence
- Technology & techniques advancing
- Staff Retention
SD Model: Stock & Flow Diagram
SD Modelling
SD Modelling - Capturing Staff Learning

- Using SD to capture the drop in experience when a new radiotherapy regime is adopted.
- This translates to a larger impact than expected on the treatment time of patients.
### DES Modelling

<table>
<thead>
<tr>
<th></th>
<th>Average Arrived</th>
<th>Average Leaving</th>
<th>Av. Completed Patients</th>
<th>Average Total Imaging Sims</th>
<th>Average Treatments Delivered</th>
<th>Total IMRT patients</th>
<th>Time to first treatment (Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>D</strong></td>
<td>6,462</td>
<td>6,301</td>
<td>97.57%</td>
<td>8,260</td>
<td>108,840</td>
<td>29.2%</td>
<td>26.22 [sd: 16.59]</td>
</tr>
<tr>
<td><strong>BASE</strong></td>
<td>6,462</td>
<td>6,149</td>
<td>94.83%</td>
<td>8,262</td>
<td>106,189</td>
<td>20.7%</td>
<td>28.52 [sd: 20.56]</td>
</tr>
</tbody>
</table>
Mixed Method Design

Identified points of interaction between the models
Mixed Modelling Insight: SD focus

• Enabled exploration of the value of changing to more complex treatment regimes
  – Time realised for activities peaks then returns to an expected level (the target level for that regime)
  – Overall progressive decrease in the number of phases required per patient
  – Progressive increase in time required on treatment machine per session per patient
  – Net effect of decrease in the contact time on treatment machines.
  – Staggered technology implementation needed to cope with the learning process involved with changing treatment regime.

... whilst accounting for the constraints and issues to be encountered in practice.
<table>
<thead>
<tr>
<th>Mixed Method Design</th>
<th>Isolationism</th>
<th>Parallel Design</th>
<th>Sequential Design</th>
<th>Enrichment Design</th>
<th>Interaction Design</th>
<th>Integration Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of possible methods under consideration</td>
<td>1 only</td>
<td>more than 1</td>
<td>1 or more</td>
<td>more than 1</td>
<td>more than 1</td>
<td>more than 1</td>
</tr>
<tr>
<td>View of the system</td>
<td>Single view of the system</td>
<td>Two possible representations of the same system</td>
<td>Need to capture different parts/behaviours of the same system</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of separable roles of each method under consideration</td>
<td>All issues fit a single method</td>
<td>Single theme requiring complementary insight</td>
<td>Single theme with separable issues</td>
<td>Single role of the methods</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interaction likely</td>
<td>-</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Direction of interaction</td>
<td>-</td>
<td>-</td>
<td>One direction</td>
<td>One OR Both directions</td>
<td>One OR Both – if only one then sequential design</td>
<td>Both directions</td>
</tr>
<tr>
<td>Form of interaction</td>
<td>-</td>
<td>-</td>
<td>Model insight and hard data</td>
<td>Hard data only</td>
<td>Model insight and hard data</td>
<td>Hard data only</td>
</tr>
<tr>
<td>Frequency of interaction over time window</td>
<td>-</td>
<td>-</td>
<td>Once – single pass</td>
<td>Low to High (Likely high)</td>
<td>Low to High (Likely low)</td>
<td>Low to High (Likely high)</td>
</tr>
<tr>
<td>Number of points of interaction</td>
<td>-</td>
<td>-</td>
<td>Single to multiple</td>
<td>Single to multiple</td>
<td>Single to multiple</td>
<td>Single or Multiple (Likely multiple)</td>
</tr>
<tr>
<td>Triggered or regular interactions</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Triggered by the state of the system AND / OR Regular, every X timesteps</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of models created</td>
<td>1 only</td>
<td>more than 1</td>
<td>more than 1</td>
<td>1 only</td>
<td>more than 1</td>
<td>1 only</td>
</tr>
</tbody>
</table>
Realised value of the modelling process

• Problem structuring ... Open to capturing a broad range of issues

• Both SD and DES have explicit roles to play
  − SD ... Enabled exploration of the value of changing to more complex treatment regimes
  − DES ... Identified process restrictions and limitations

• Used to develop understanding of the system
  − ... whilst building a case for/against policy changes
  − Overall benefit to equity of care
Realised value of mixing DES & SD

• From the client’s perspective ...
  - Challenged beliefs about behaviour of the system
  - ... leading to a change in understanding by stakeholders
  - ... effect on the culture of the centre

• From the modeller’s perspective ...
  - Challenged personal perceptions of the system
  - Requisite modelling .... Cycling between methods encouraged explicit consideration of what is really needed in the models
Discussion

• Mixing methods is valuable to capture complex problems

• Concerns
  – A desire to model everything
  – Possible to obtain the value from both methods ... but at what price?

• Value
  – Encouraged an open view of the issues ... different method world views
  – Client acceptance & buy-in
Key learning points

1. Commonality/overlap of the methods

2. Set of mixed method designs to categorise mixed methods projects

3. A general mixed method model development process

4. Practical challenges and value of mixing methods
   - Distinct roles of methods within the action research project
   - It need not be technically challenging, and needs conceptual support