A Smart City Case Example: Toward an Integrative Learning Design Framework for Research, Design and Analysis

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A Case Example for Smart Cities R&D

- Learning and Design – important for Smart City Initiatives
- Smart Cities “Learning” Case
- Application of phases of the Integrative Learning Design Model
- Focus on human-centered design processes
- Community involvement through participatory design
- Expanding educational and design process tools to promote discovery, innovation and entrepreneurship for Smart Cities initiatives
- Supporting the generation of new partnerships & smart city solutions
Beyond Smart Cities and Learning

“...although several kinds of learning systems can be observed, the process of learning may be as important as the product in contributing to sustainable outcomes.”

- Dr. Joan Clos, United Nations Under Secretary and Executive Director, UN-HABITAT

Smart Cities

“...to really achieve smart cities – that is, to create the conditions of continuous learning and innovation – this book argues that there is a need to understand what is below the surface and to examine the mechanisms which affect the way cities learn and then connect together.”

Design Process

While the underlying technology enables, it’s really design that establishes [a product] in people’s lives. So, you really have to treat design as important as software and hardware.


Smart City Learning through Design

“...a grand challenge for the near future will be to promote the integration of the functionalist top-down vision of the Smart Cities with a bottom-up vision driven by a "person centered in place“ design approach supporting the harmonious development of all relevant dimensions of the human experience; within this approach the "smart learning" is considered to be one of the driving forces of the “smartness” of a community.”

Ecosystem for Smart Medical Training
Design Context and Design Process

“Context is everything, design has taught us this. To document and to understand the contextual factors that make or break a good idea are one of the most important things that I think the design profession can help cities with.”

- Tim Campbell, Beyond Smart Cities

Ecosystem for Smart Medical Team Training

A cyber-physical network of IoT and simulations for medical training and enhanced team performance.

Goals:
- Enhanced Simulation Debrief and Learning
- Improved Trauma, Medical, and Surgical Team Performance
- Improved Patient Care
Informed Exploration
City Problem

Medical, surgical and emergency response teams are required to quickly comprehend a complex array of factors including time, situational awareness, coordination of team/individual actions, as well as manage physiological stress, any of which can impair performance in high stakes situations.

Context

• Simulation can improve emergency response and patient care
• Dynamic interaction is key to developing team situation awareness
• Behavioral as well as cognitive factors are notoriously difficult to measure in complex team simulation environments.

Source: Haji, et al. (2009); Salas, et al. (2009); Rosen et al. (2008)
Challenge/Goal

- In the Field, In Transport to Hospital Emergency Department and Surgery

- Deploy real-time tracking system recording activity/experience during high-fidelity, multi-team simulations
- To test a technology proof-of-concept and gather input toward:
  - improving emergency response and medical team reflection and learning from live action simulation exercise
  - to strive toward impacting individual and team performance in city-based emergencies
Community

- Fire Chief
- Fire & Rescue Department Medical Director
- Chief of Surgery
- Emergency Department Trauma Surgeon & Staff
- Physicians, residents, fellows, nurses, OR techs, etc.
- Healthcare simulation experts
- Government agency initiative
- Analytics and hardware start-up companies
- Volunteers/Expertise:
  - Learning technology, engineering, human factors, computer science, programmers, instructional designers, graduate students, undergraduate students, high school students
Deep Dive
Learning System Pain Points

Pain points in the journey map are opportunities for improvement and places where contextual design can likely make a big difference in improving your [customer] experience.

- Abi Jones, interaction designer, Google

Learning Systems are more than just software tools. Learning Systems are purposed arrangements of relationships between people, information, technology, and spaces.

- Ben Erlandson, CTO of McKinsey Social Initiative

Source: http://benerlandson.net/2015/07/learning-systems-design/
Contextual Analysis

• Observation/Interviews/Focus Groups
  • Advanced Surgical Technology Education Center (ASTEC)
  • Emergency Department INOVA Fairfax Hospital
  • Fairfax Fire & Rescue Academy

• Pain Points Identified
  • Complexity of Live-Action, Multi-team Simulation
  • Patient hand-off between EMS and Medical teams
  • Team dynamics and coordination
  • Team-based and individual reflection, learning, performance in debrief
Enactment
Target

• Can we track individual and team behavior (leveraging Bluetooth proximity beacons) in a live-action, multi-team simulation context automatically and invisibly?

• Can we display real-time information about the simulation in the debrief related to individual and team actions?
Coordination

- Firefighters coordinate their actions implicitly by observing the actions of their team members
  - wearable computing can provide details on group dynamics by automatically measuring how group structure changes during a mission
  - a graphical representation of who was when in close proximity to whom illustrates mission development over time
  - Allows instructors to pinpoint possible coordination problems
  - Communities and routines of persons can be identified from Bluetooth proximity networks

Source: Feese, S. et al. (2013). Sensing group proximity dynamics of firefighting teams using smartphones. ISWC ’1, September 9-12, 2013, Zurich, Switzerland.
Learning and Performance

• **Impact Situation Awareness?**
  • “...reception of the elements in the environment within a volume of time and space and the comprehension of their meaning, and the projection of their status in the near future.”

• **Impact Collaborative Reflection?**
  • “...those intellectual and affective activities in which individuals engage to explore their experiences in order to lead to new understandings and appreciations”
    • By supporting model of reflection - by returning to the experience through immediate, detailed display of actions, time, proximity

Build to Think
Design - Human-centered

• “What we saw early on was that design, for whatever reason, was a methodology, was nonthreatening. It’s all so human-centered, so when you got people from different backgrounds together and you said, “Ok, let’s go out and build empathy for the people we’re trying to help…”

Iterate

• “If you can just tell me who was in the room, of who was actually supposed to be in the room, and the location of the patient at all times, that is good enough for me.”
  • Dr. Maggie Griffen, M.D., Trauma Surgeon INOVA Fairfax
xAPI/LRS System

Interoperable, flexible, granular way to track experiences, scores, progress, teams, virtual media, real-world experiences ...

Human readable statements stored in a learning record store (LRS - Cloud-based data store typically using a no-SQL Db)

- Activity aggregation for meaning
- Recommender engines
- Real-time reporting and stats

Source: Advanced Distributed Learning – adlnet.gov
1) In the Field

2) In Transit

3) In the ER

4) In the OR

- Timestamp
- GPS Coordinates
- Handoff Checklist

EMS-1, EMS-2, EMS-3

Local LRS

LRS

= Radius Network Beacon

Patient Z1

Network Beacon

Network Beacon

Network Beacon
Iterate
Generate

Trauma bay entrance (cell phone listening device) “detected” EMT1 (receiver beacon) (actor, verb, object) processed in LRS for display

<Trauma bay location cellphone><detected><EMT1>

<EMT1@gmail.com><entered><zone 3>
<EMT2@gmail.com><entered><zone 3>
<EMT_Team1Q><entered><zone 1>
<EMT_Team1Q><arrived><onsite> (true) {GPS coordinates}
<EMT1@gmail.com><check><heartrate> (60bps)
Evaluation
Smart Teams EMS Activity Tracker

**Event Initialization**
- Dispatch Call Received
- Ambulance Arrives
- Engine Crew Arrives

**Patient Care**
- Primary Care Survey Complete
- C-collar Applied
- Patient on Back Board
- IV Established
- IV Fluids Given
- Intubation
- Chest Compression
- Dopamine Given
- GCS Completed

**Transport**
- Untitled Question
- Depart Scene
- ETA 5-15 minutes
- ETA less than 5 minutes
- Enter Hospital Driveway

**Vital Signs**
- Glasgow Coma Scale Score
  - Less than 8
  - 8 or higher

- Blood Pressure

- Heart Rate
<table>
<thead>
<tr>
<th>Event Type</th>
<th>Description</th>
<th>Timestamp</th>
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<tbody>
<tr>
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<td>Dispatch Call Received</td>
<td>5/21/2015 9:18:59</td>
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<tr>
<td>Patient Care</td>
<td>C-collar Applied</td>
<td>5/21/2015 9:22:45</td>
</tr>
<tr>
<td>Patient Care</td>
<td>Patient on Back Board</td>
<td>5/21/2015 9:25:07</td>
</tr>
<tr>
<td>Patient Care</td>
<td>Primary Care Survey Complete</td>
<td>5/21/2015 9:25:07</td>
</tr>
<tr>
<td>Timestamp</td>
<td></td>
<td>5/21/2015 9:30:12</td>
</tr>
<tr>
<td>Patient Care</td>
<td>Depart Scene</td>
<td>5/21/2015 9:34:53</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>Established</td>
<td>5/21/2015 9:32:04</td>
</tr>
<tr>
<td>Blood Pressure</td>
<td>Established</td>
<td>5/21/2015 9:36:25</td>
</tr>
<tr>
<td>Patient Care</td>
<td>GCS Completed</td>
<td>5/21/2015 9:36:57</td>
</tr>
<tr>
<td>Glasgow Score</td>
<td>8 or higher</td>
<td>5/21/2015 9:38:20</td>
</tr>
<tr>
<td>Blood Pressure</td>
<td>85/40</td>
<td>5/21/2015 9:44:21</td>
</tr>
<tr>
<td>Patient Care</td>
<td>IV Fluids Given</td>
<td>5/21/2015 9:45:15</td>
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<tr>
<td>Timestamp</td>
<td></td>
<td>5/21/2015 9:48:45</td>
</tr>
<tr>
<td>Transport</td>
<td>ETA less than 5 minutes</td>
<td>5/21/2015 9:52:14</td>
</tr>
<tr>
<td>Transport</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enter Hospital Driveway</td>
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</table>
# Smart Teams Learning
## Temporal Analytics

<table>
<thead>
<tr>
<th>Temporal Data</th>
<th>Logistics</th>
<th>Patient Care</th>
<th>Vitals</th>
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<tbody>
<tr>
<td></td>
<td>Elapsed Time</td>
<td>Time From Prior Event</td>
<td>Glasgow Score</td>
</tr>
<tr>
<td>9:18:59</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>9:22:45</td>
<td>0:03:45</td>
<td>0:03:45</td>
<td></td>
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<tr>
<td>9:25:07</td>
<td>0:06:07</td>
<td>0:02:22</td>
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<td>9:29:37</td>
<td>0:10:38</td>
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<td>9:30:12</td>
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<td>9:32:04</td>
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<td>0:01:23</td>
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</tr>
<tr>
<td>9:34:53</td>
<td>0:15:53</td>
<td>0:02:49</td>
<td></td>
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<td>9:35:26</td>
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<td>0:01:32</td>
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<tr>
<td>9:36:57</td>
<td>0:17:57</td>
<td>0:00:32</td>
<td>GCS Completed</td>
</tr>
<tr>
<td>9:38:20</td>
<td>0:19:21</td>
<td>0:01:23</td>
<td>8 or higher</td>
</tr>
<tr>
<td>9:44:21</td>
<td>0:25:22</td>
<td>0:06:01</td>
<td></td>
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<td>9:45:16</td>
<td>0:26:15</td>
<td>0:00:54</td>
<td>IV Fluids Given</td>
</tr>
<tr>
<td>9:48:45</td>
<td>0:29:46</td>
<td>0:03:30</td>
<td>ETA less than 5 minutes</td>
</tr>
<tr>
<td>9:52:14</td>
<td>0:33:15</td>
<td>0:03:29</td>
<td></td>
</tr>
</tbody>
</table>

## KPI's

<table>
<thead>
<tr>
<th>KPI's</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispatch to Depart Scene</td>
<td>0:11:13</td>
</tr>
<tr>
<td>IV established to IV fluids given</td>
<td>0:14:34</td>
</tr>
<tr>
<td>Depart Scene to Enter Hospital Driveway</td>
<td>0:22:02</td>
</tr>
<tr>
<td>Total Elapsed Time</td>
<td>0:33:15</td>
</tr>
</tbody>
</table>
Preliminary Real-time xAPI Data
Preliminary Subsequent xAPI Data

Figure 1. Personnel beacon detections by time with locations overlaid (experiment from May, 2015). Color codes are used for each beacon that was handed to one person. The beacon stayed with one person throughout the simulated experiment.
Figure 1. A compilation of all available beacon data. Colored circles indicate individual health care workers in proximity of a sensor (sizes are arbitrary and variable only such that individuals can be distinguished). Additional overlaid data includes data collected via checklist and heart rate data during transport. All times are accurate to the simulation day.
Participatory

• “It’s not always as smooth as this...it could really help in team dynamics.”
  • Medical Resident

• “We all think we are doing these things in a timely manner, but we really don’t know.”
  • Trauma surgeon

• Tracking of actions/proximity to objects would be useful for:
  • When ultrasound probe is picked up, when manual cuff is placed, when doors to blood bank are opened, when you pick up the I-stat machine, etc.

• Efficiency, effectiveness, and time-based information would be valuable

• Potential to translate into team performance related to situation awareness, team coordination, observation and reflection
Suggestions

• Replicate multi-team simulation with additional behavior tracking
  • Incorporate fine-grain actions with equipment in trauma bay
  • potentially include surgical context
• Provide invisible data collection to not interfere with work flow
  • Particularly related to electronic checklist in ambulance
• Incorporate collection of critical verbal statements
  • Not all statements, just selective recording triggered through audio
• Incorporate biometric data collection measure individual/team stress in-situ
• Provide contiguous individual real-time activity streams
  • Who is doing what simultaneously
• Improve display and visualization of data in debrief
• Iterate system and process approach to replicate and customize approach/system
Learning and Outcomes

• Application of Integrative Learning Design Framework
• Research
  • Multiple research directions resulted – Smart Cities, IoT, healthcare, team science
  • Interdisciplinary Research Team – Smart City Design Research Cycle
  • Grounded in both practice and research
  • Can Frame Problem – targeting behavior, learning and performance, outcomes
  • Pilot data from proof-of-concept to iteratively inform new studies – video analysis
  • xAPI as a behavioral tracking method real world team-based environments
  • Incorporate other digital devices – wearable, sensors, etc.

• Design
  • Complexity of designing for IoT for smart city learning
  • Human-centered and experience design orientation
  • Participant design in iterative cycles
  • Contextual analysis is crucial - what is important in this particular context
  • Generate innovation with community - leveraging xAPI, new devices, for medical space
  • Establish trust with stakeholders through design cycles
  • New Directions in Design – distinguish smart cities learning design, design for IoT systems

• Analysis
  • Visualization – making information meaningful
  • Iterative – feedback loops in improving design, research, analysis
  • Incorporate additional big data and visualization experts
  • Systems perspective – organizations, culture, roles, activities, interprofessional team interaction
  • Learn from success as well as failures/breakdowns
Informed Exploration

Questions:
What are identified gaps and problems in city?
What information can be gleaned or adapted from research, applications, other cities?
How to characterize or frame problem with stakeholders?
What are city-based systemic, cultural, social influences?
How to build alliances/working/design groups and trust for new ideas in this city?
Generate ideas for solutions – informal and formal channels, top-down and bottom-up?

Methods:
Analysis of city readiness
Needs/Performance analysis
Identify networks
Problem identification
Design Inquiry
Contextual analysis
Comparative analysis
Bottom up/top down
Informal/formal design exchanges
Surveys
Interviews
Benchmarking
Case studies

Enactment

Questions:
What is the learning or performance targets for the system innovation?
How to generate multiple ideas at multiple scales based on target?
How do we narrow focus for system proof-of-concept?
What many-to-many interactions are possible?
How is the system especially applicable for this city?
What are the system levers, drivers or outcomes that can demonstrate impact on the problem?

Methods:
Identify learning and performance targets and outcomes
Participatory Design
Generative design methods
Expert Panels
City visits
Parallel workgroups
Design Reviews with Citizens, Stakeholders
Best Practices generation
Technical workshops
Integrate Interdisciplinary knowledge and methods

Evaluation: Local Impact

Questions:
Is the enacted designed system usable and relevant to users, stakeholders?
Can we iterate from proof-of-concept to build and refine?
What elements of the system should be refined?
What ROI, measures or metrics?
What impact or system effectiveness can be determined?

Methods
Determine applicable evaluation methods such as:
Feasibility testing, Pilot testing, Usability testing, expert review, formative evaluation

Evaluation: Broad Impact

Questions:
What factors may influence the adoption, adaptation and diffusion of this system?
What are incentives for sharing ideas and reuse?
How does the new system influence the quality of life of citizens?
What new problems or issues emerge?
What policies and cultures shape citizen use or non-use of the system?
What are mechanisms for sharing data, models, software, hardware, etc.?
What is the business value of the system?
How to scale innovation system?

Methods
Surveys
Qualitative Research
Quantitative Research
Big Data Analysis
Social Network analysis
Others?

Methods
Surveys
Qualitative Research
Quantitative Research
Big Data Analysis
Social Network analysis
Others?

Some concepts adapted from: Townsend, A. ( ). Smart Cities: Big Data, Civic Hackers, and the Quest for a
Conclusion

“...sees city learning as a collective process, which always starts with discovery by individuals”
- Tim Campbell, Beyond Smart Cities

• Focus for Smart Cities – on more than just the technology system
  • Need Smart City “Learning” focus and Design Research Process
  • Access, Inclusive and Participatory – involve community members in design
  • Formal and informal learning channels
  • Top down AND bottom up
  • Interdisciplinary and team science perspectives
  • Human-centered, Experience Design, IoT Design, Interdisciplinary Smart City Design

• Smart City R&D, Funding and Education of Smart Citizens and Communities
  • Integrative Learning Design Framework for Smart Cities to begin to address
    • To Unpack and Intervene in Complexity and Complex Systems
    • Systematic Approach
  • Smart City Design Research – study process and cases of smart city learning
  • Study Case Examples
  • Study Scaling and Adaptation to other contexts

Thank You

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References


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