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

Source: Campbell, T. (2012). Foreward. Beyond Smart Cities: How Cities Network, Learn and Innovate. New York: Routledge.

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 <u>need to understand what is below the surface and to examine the mechanisms which affect the way cities learn and then connect together</u>."

Source: Campbell, T. (2012). Introduction. Beyond Smart Cities: How Cities Network, Learn and Innovate. New York: Routledge.

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.

- Interview with Robert Brunner, Founder, Ammunition Design Studio, The World’s Top 10 Most Innovative Companies in Design of 2015 Fast Company Magazine

Source: Avoid design pitfalls in the IoT: Keep the focus on people - O'Reilly Radar Interview with Robert Brunner. (n.d.). Retrieved from http://radar.oreilly.com/2015/07/avoid-design-pitfalls-in-the-iot-keep-the-focus-on-people.html

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."

Source: Giovannella, et al. (2013). IEEE 13th International Conference on Advanced Learning Technologies.

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

Source: Beyond Smart Cities: An Interview with Tim Campbell Part I . Retrieved at http://opensourcecities.tumblr.com/post/10451972076/timcampbell

Ecosystem for Smart Medical Team Training

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

Simulation: Training

LRS Learning Record Store

Goals:

- Enhanced Simulation Debrief and Learning
- Improved Trauma, Medical, and Surgical Team Performance
- Improved Patient Care

INOVA

verizon

Fairfax County Fire and Rescue

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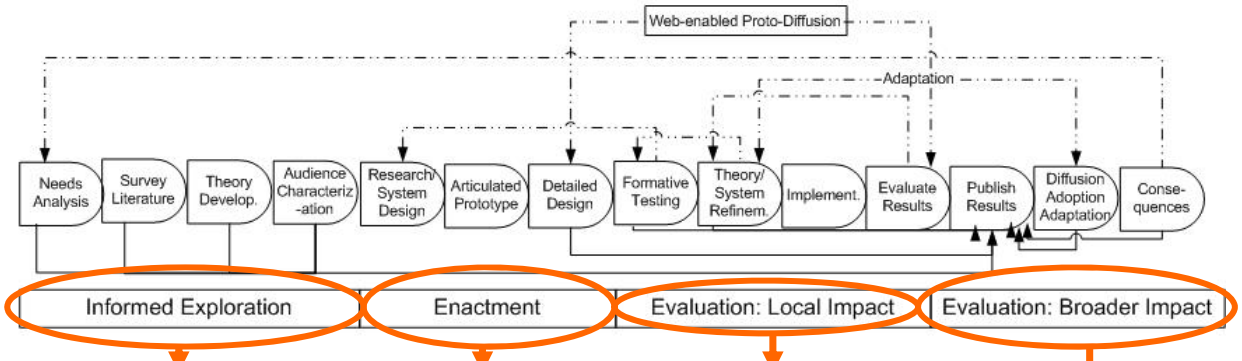
Figure 1
Questions and Methods for Design Research by ILDF Phase



ILD	Informed Exploration	Enactment	Evaluation: Local Impact	Evaluation: Broader Impact
Guiding Questions for Research	Questions: What are identified gaps/problems in theory, practice, and/or the marketplace? What information can be gleaned from existing data or research? How can we characterize the problem or learner need? What are the systemic social, cultural, and organizational influences or constraints on design? What are characteristics of the audience?	Questions: What are the learning targets for innovation? What design principles or strategies may be applicable? How to identify and operationalize cognitive and performance processes in design? To what extent does the design embody the theoretical model?	Questions: Is the enacted design usable, valid and relevant? Is the design instance accessible and efficient in delivering instruction or supporting learning? What is the local impact or effectiveness of the design instance? How effective is the design solution in achieving learning targets at its highest fidelity in full context?	Questions: What factors influence diffusion, adoption and adaption of innovation? What are the pragmatic demands of the learning environment that influences adoption of design? What policies and cultures shape participants use of innovation?
Applicable Research Methods	Methods: Benchmarking Performance/needs analysis Interviews Survey of Experts Focus Groups Observations/Role Modeling Case Studies	Methods: Task Analysis Contextual Analysis Designer Logs Expert Review Audience Review	Methods: Usability Testing Expert Review Observation or Video records Interviews Formative Evaluation Pre-post Comparative Studies Quasi-experimental studies	Methods: Analysis of computer log files Multi-site Interviews, Surveys and Observations Data mining Correlational studies Quasi-experimental studies

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.

Source: Arora, et al. (2009) The impact of stress on surgical performance: A systematic review of the literature. *Surgery* 147(3), 318-330

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

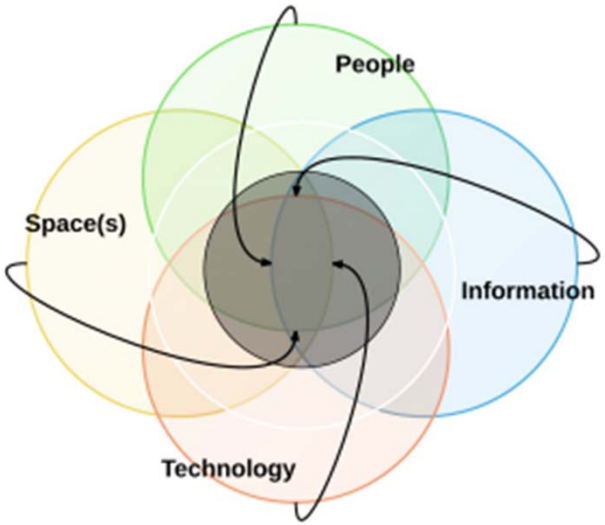
Learning System Pain Points

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

Source: Endsley, (1995). Toward a theory of Situation Awareness in dynamic systems. Human Factors, 37 (1), 32-64, p.36.; Boad, D., Keogh, R. & Walker, D. (1985). Reflection: Turning experience into learning. New York: Routledge


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…”

Source: An Interview with David Kelly (2013). The origin of the d.school at Stanford University. Retrieved from http://rethinked.org/?p=4452

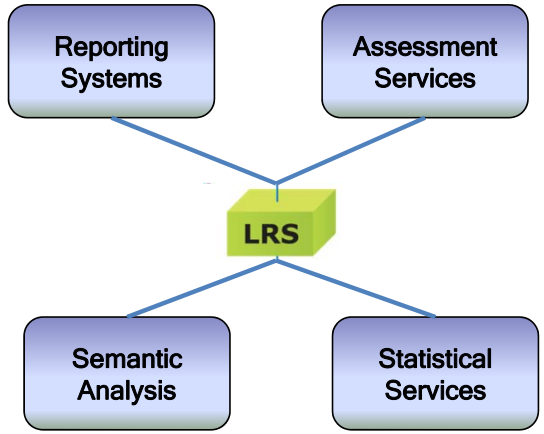
Iterate

- “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

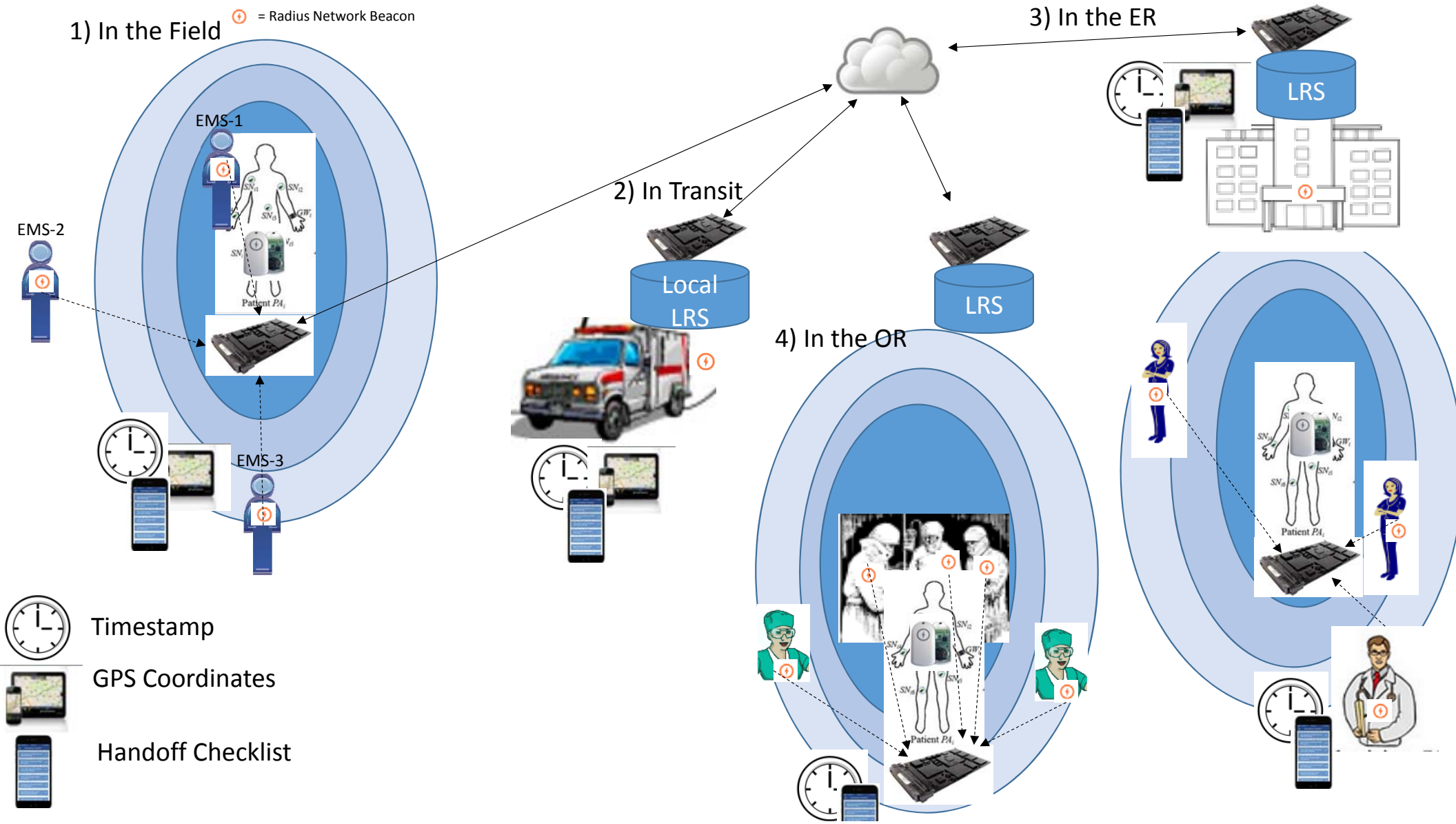
Interoperable, flexible, granular way to track experiences, scores, progress, teams, virtual media, real-world experiences …

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

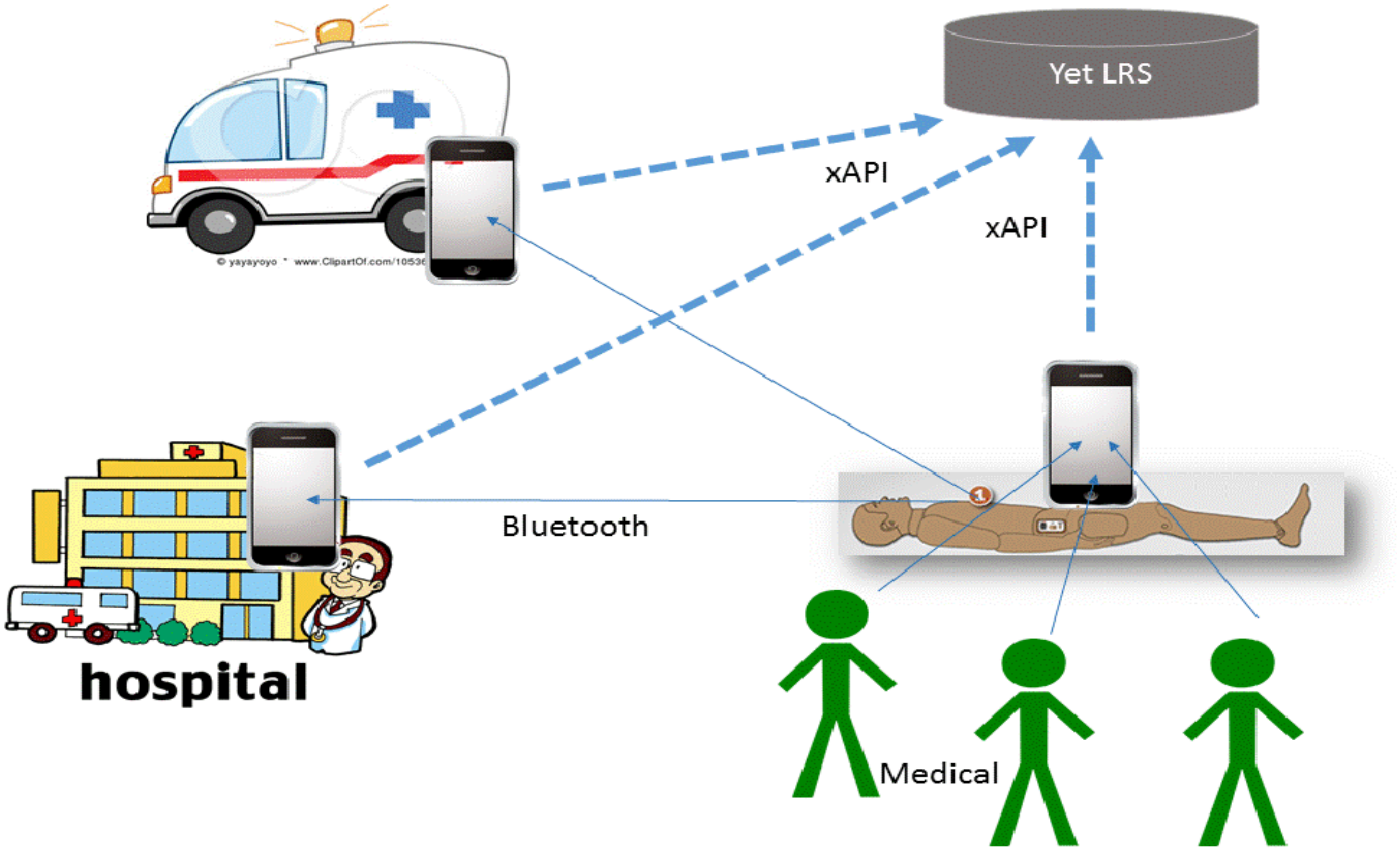


- Activity aggregation for meaning
- Recommender engines
- Real-time reporting and stats

Source: Advanced Distributed Learning – adlnet.gov


= Radius Network Beacon
1) In the Field
EMS-1
EMS-2
EMS-3
2) In Transit
Local LRS
3) In the ER
LRS
4) In the OR
LRS
Timestamp
GPS Coordinates
Handoff Checklist

Iterate



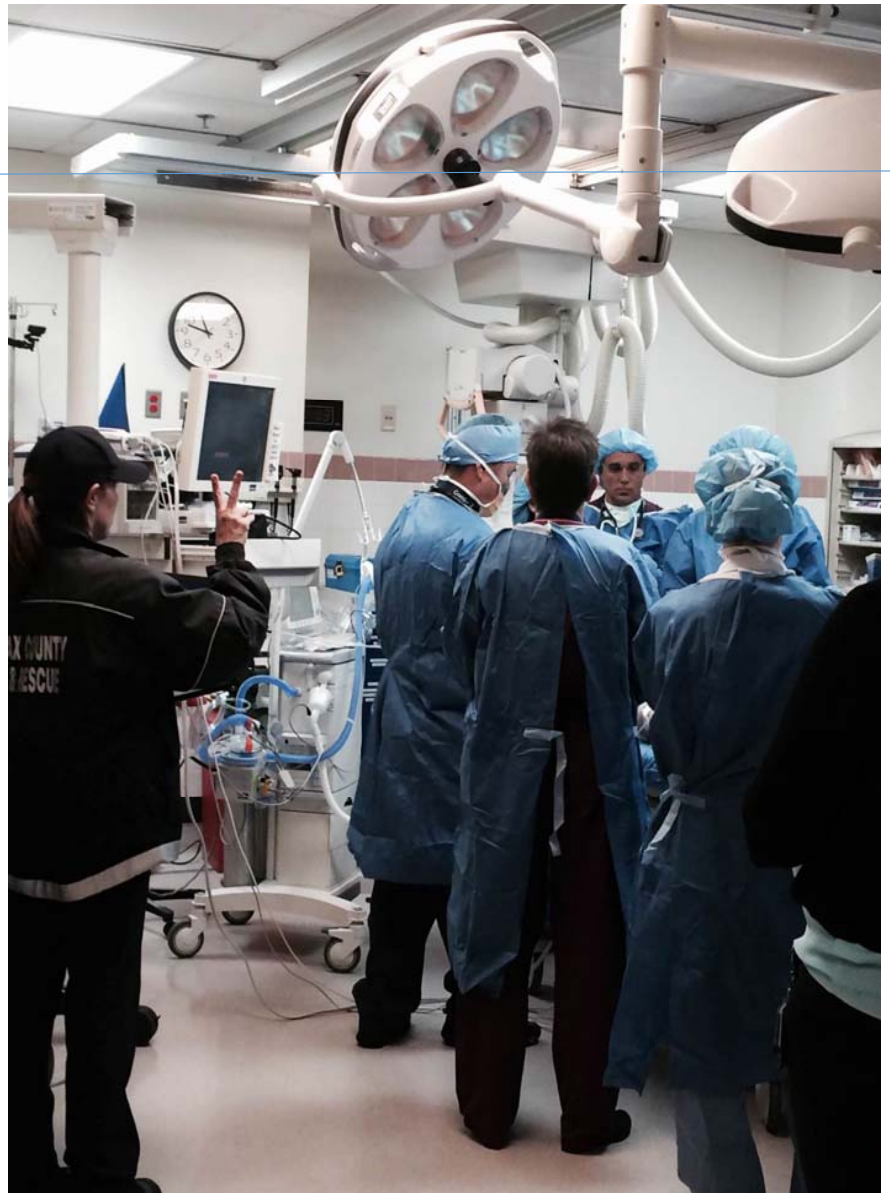
Generate

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 Intitialization

- [ ] 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

Real-time EMS Activity Monitor

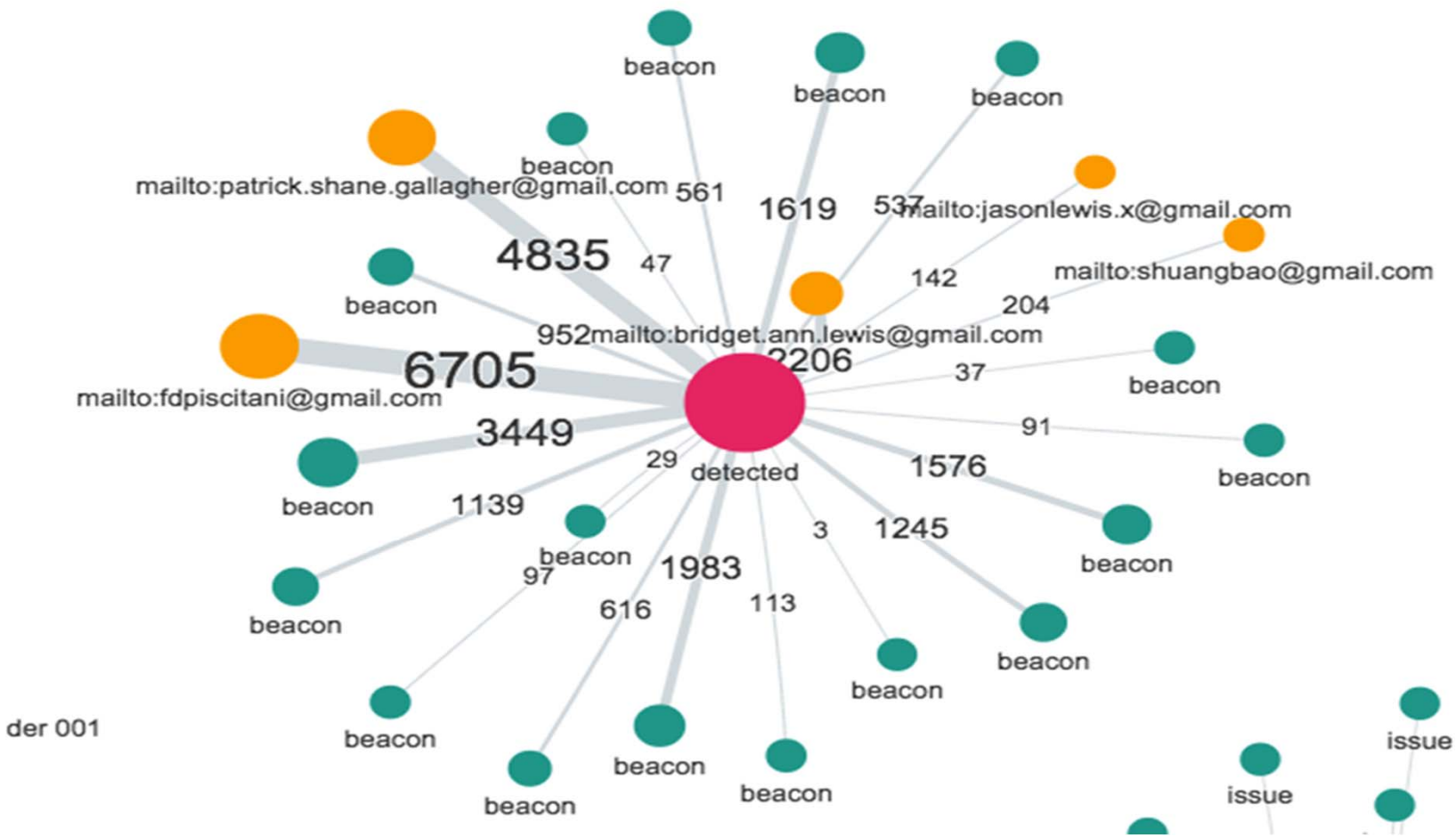
- initialize: Dispatch Call Received, timestamp: 5/21/2015 9:18:59
- patientcare: C-collar Applied, timestamp: 5/21/2015 9:22:45
- patientcare: Patient on Back Board, timestamp: 5/21/2015 9:25:07
- patientcare: Primary Care Survey Complete, timestamp: 5/21/2015
- timestamp: 5/21/2015 9:30:12, transport: Depart Scene
- patientcare: IV Established, timestamp: 5/21/2015 9:30:41
- heartrate: 110, timestamp: 5/21/2015 9:32:04
- patientcare: IV Established, timestamp: 5/21/2015 9:34:53
- bloodpressure: 115/65, heartrate: 100, timestamp: 5/21/2015 9:36:25
- patientcare: GCS Completed, timestamp: 5/21/2015 9:36:57
- glasgowscore: 8 or higher, timestamp: 5/21/2015 9:38:20
- bloodpressure: 85/40, heartrate: 130, timestamp: 5/21/2015 9:44:21
- patientcare: IV Fluids Given, timestamp: 5/21/2015 9:45:15
- timestamp: 5/21/2015 9:48:45, transport: ETA less than 5 minutes
- timestamp: 5/21/2015 9:52:14, transport: Enter Hospital Driveway

Smart Teams Learning
Temporal Analytics

Temporal Data			Logistics	Patient Care	Vitals		
hr:min:sec	Elapsed Time	Time From Prior Event			Glasgow Score	Blood Pressure	Heart Rate
9:18:59			Dispatch Call Received				
9:22:45	0:03:45	0:03:45		C-collar Applied			
9:25:07	0:06:07	0:02:22		Patient on Back Board			
9:29:37	0:10:38	0:04:30		Primary Care Survey Complete			
9:30:12	0:11:13	0:00:35	Depart Scene				
9:30:41	0:11:42	0:00:29		IV Established			
9:32:04	0:13:05	0:01:23					110
9:34:53	0:15:53	0:02:49		IV Established			
9:36:25	0:17:26	0:01:32				115/65	100
9:36:57	0:17:57	0:00:32		GCS Completed			
9:38:20	0:19:21	0:01:23			8 or higher		
9:44:21	0:25:22	0:06:01				85/40	130
9:45:15	0:26:15	0:00:54		IV Fluids Given			
9:48:45	0:29:46	0:03:30	ETA less than 5 minutes				
9:52:14	0:33:15	0:03:29	Enter Hospital Driveway				

KPI's	Value
Dispatch to Depart Scene	0:11:13
IV established to IV fluids given	0:14:34
Depart Scene to Enter Hospital Driveway	0:22:02
Total Elapsed Time	0:33:15

Preliminary Real-time xAPI Data



Preliminary Subsequent xAPI Data

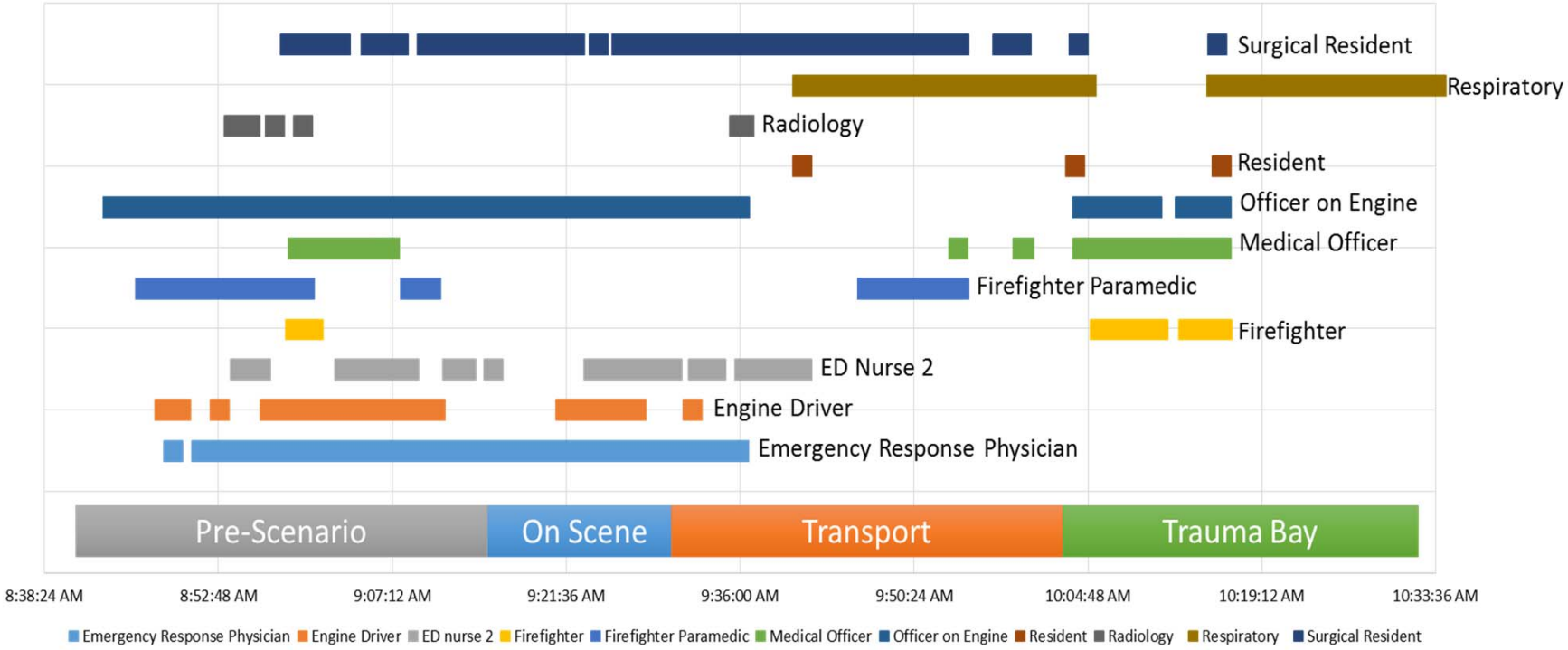


Figure 1. Personnel beacon detections by time with locations overlaid (experiment from May, 2015). Color codes are used for each beacon that was handed to one person. The beacon stayed with one person throughout the simulated experiment.

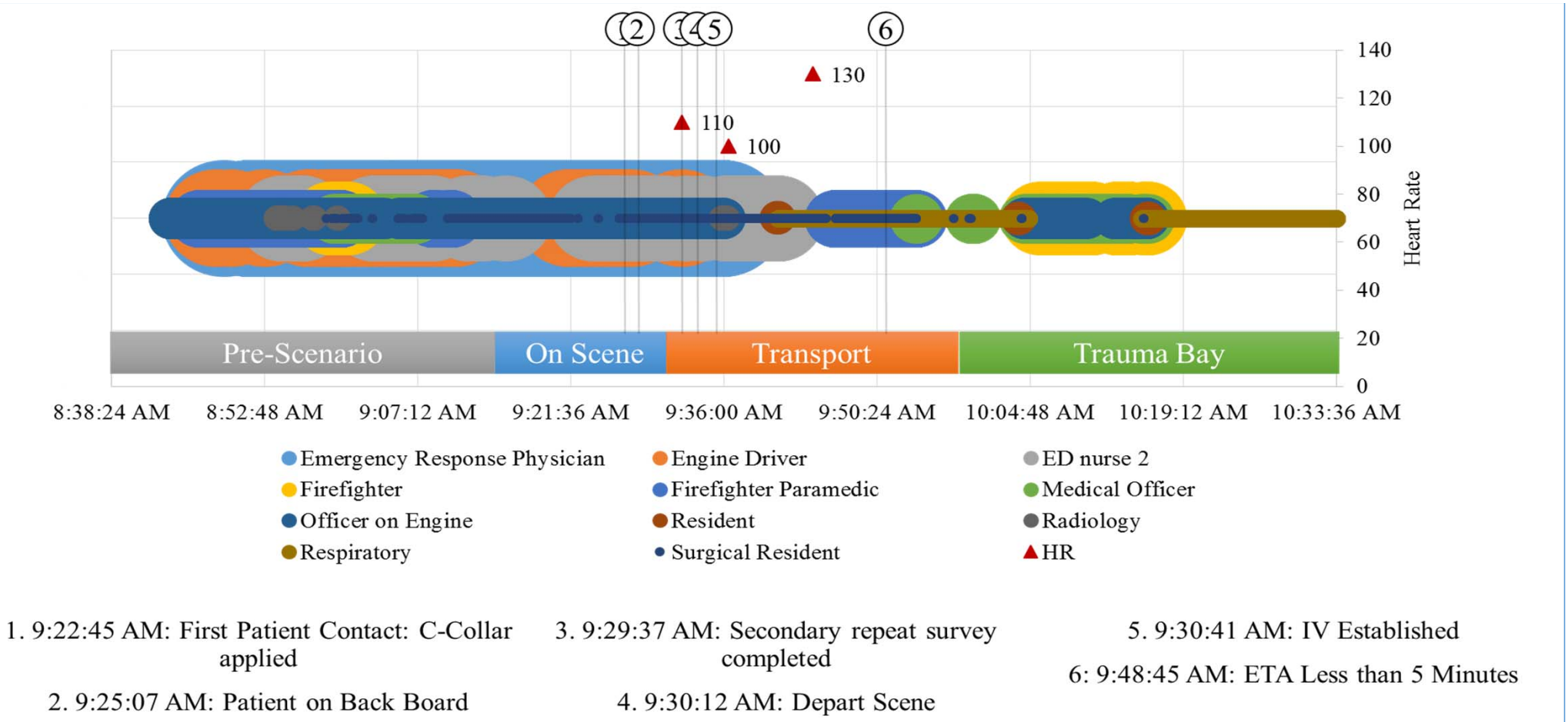


Figure 1. A compilation of all available beacon data. Colored circles indicate individual health care workers in proximity of a sensor (sizes are arbitrary and variable only such that individuals can be distinguished). Additional overlaid data includes data collected via checklist and heart rate data during transport. All times are accurate to the simulation day.

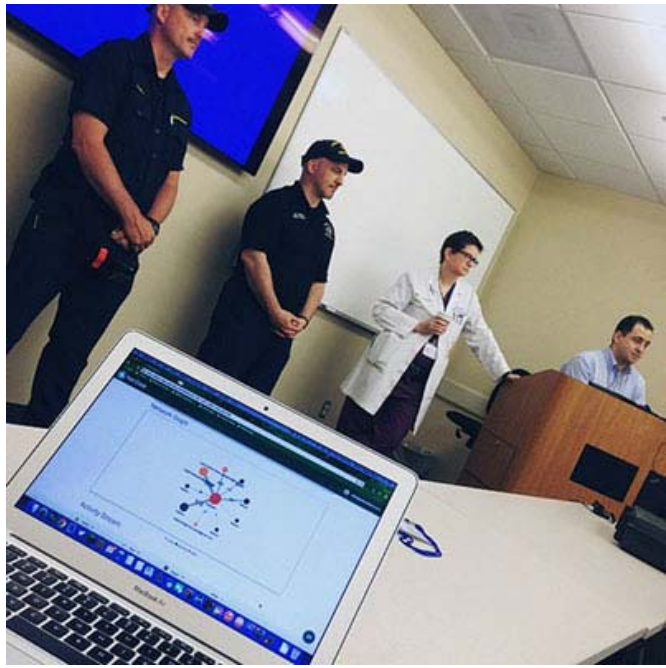
Participatory

- “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	Enactment	Evaluation: Local Impact	Evaluation: Broad Impact
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?	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?	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?	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: 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	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	Methods Determine applicable evaluation methods such as: Feasibility testing, Pilot testing, Usability testing, expert review, formative evaluation Determine applicable applied and empirical research methods such as: observation, video analysis, Identify metrics and outcomes at various levels Formative evaluation Usability testing Pilot testing Document design reviews Iterative and agile revision	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

Source: Campbell, T. (2012). Introduction. Beyond Smart Cities: How Cities Network, Learn and Innovate. New York: Routledge.

Thank You

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