Author Accepted Manuscript (AAM).
Version of record: Lister, P. (2016). Evaluating Smart City Learning. In Antoine Zammit and Therese Kenna (Eds.), Enhancing Places through Technology. Proceedings from the ICiTy conference Valletta, Malta - 18-19 April, 2016, page 241 - 255. ISBN: 9789897570551

Evaluating Smart City Learning

Penelope J Lister, PhD researcher, MSc MA MBCS FHEA

Abstract

Measurement and analysis of individually interpreted learning experiences can build a knowledge picture of how learners perceive immersive technology-mediated learning in smart cities. Comparison of these learning experiences with theoretical factors derived from relevant literature may then shed light on the usefulness of theory in practical learning design and approaches to the evaluation of immersive learning environments analysed from a theoretical basis. In turn this may contribute to current approaches of urban smart city environment planning for citizen engaged 'human smart cities' (Giovanella et al., 2016).

Mobile learning location-based prototypes will be developed with subject experts and implemented in open (urban) spaces located at Upper Barrakka Gardens, Valletta for history and Argotti Gardens, Floriana for botany. This paper discusses potential methodologies for designing a measurement of the effectiveness of these learning experiences and associated learning design for immersive urban learning environments mediated by mobile and networked technologies.

Acknowledging the hybrid nature (Cook et al., 2013) of smart city learning, interactions between digital tools, content and community, measuring both intra- and inter-learner experiences is anticipated. Identifying and quantifying these dimensions of interactions will help us understand more about how urban smart learning activities create immersive experiences for each learner, engaging them in a variety of internal cognitive and social processes. To clarify mutual interaction between theoretical and empirical factors, a system of theoretical factors of significance is proposed to be developed and then be correlated with learning experience analysis factors.

A brief review of hybrid learning environment research including ubiquitous learning (Bonanno, 2011) manifested in hybrid (Cook et al., 2013), mobile (Cochrane, T, 2014) and smart city (Andone et al., 2014, Buchem & Pérez-Sanagustín, 2013) environments provide context for how analysis methodology might be applied to an interactive learning system in smart cities. Phenomenography techniques of variation and outcome space are investigated, together with the Dialogic Space concept (Wegerif & Yang, 2011) of conversation interaction for analyzing dialogues.

Introduction

An evaluation system is being proposed to measure effective learning, considering the learner, the underlying design and the authentic immersive environment (Pérez-Sanagustín et al, 2013), using pedagogical theory as a basis for measurement approaches. The design of the evaluation system must be versatile in order to measure and analyse the proposed learning experiences, and then to make measurable connections with theoretical factors derived from an analysis of relevant theory and research discourse.

The context of the learner

The context of the learner considers how learners interpret their own experiences in relation to a number of factors, both internal and external (Rogers, C, 1951). These include learner's individual interpretations of the learning task, affordance to achieve the task, overall engagement level of the task (interest, value, purpose, perceived usefulness), or other factors in relation to the individual and their own perceptions of the context. The notion of multiple interpretations within a single individual will be acknowledged and attempt to be measured in relation to factors such as identity and role in the network (Boyd, 1993, Rogers, 1951, Siemens, 2004, Aveling et al., 2014) knowledge construction dialogue (Siemens, 2004, Ravenscroft, 2011) and concept-sharing in a dialogic space (Wegerif & Yang, 2011).

The context of the learning design

The context of the learning design is defined here as incorporating the pedagogical approach taken in the (explicit or implicit) design, the affordance of digital tool(s), the interface design in relation to the learning design (Amershi et al., 2005), the 'target audiences' of the learning design, and the authentic space in which the learning is designed for promoting participation (Cochrane, 2014, Sharples et al., 2013, Buchem & Pérez-Sanagustín, 2013, Bonanno, 2011).

The context of the authentic environment

The context of the authentic environment is defined here as learning experiences located in geo-responsive physical environments that mediate interactions between persons, technology and the ubiquitous learning (Bonanno, 2011) space around them. These experiences may involve synchronous and asynchronous individual interactions with content and a community of learners in the network of participants of the learning experience (Siemens, 2005), with digital tools mediating those experiences and facilitating the storage of constructed knowledge in the system (Siemens, 2004, Bonanno, 2014).

Mobile learning, WAY-Cyberparks and Smart Data

Mobile learning (ML) prototypes will be developed with subject experts and implemented in open (urban) spaces. At the **Upper Barrakka Gardens, Valletta** the ML activity is about an identified historical event and in the **Argotti Gardens, Floriana** about the history and architecture of the place and about the potential learning experiences in botany that can be developed at this site. Plans for using similar mobile learning location-based prototypes for other information rich spaces related to different curricular areas such as visual and performing arts will be developed and evaluated as the project progresses. These mobile learning experiences will be mediated by the Way-Cyberparks application (an EU COST funded project research initiative). "CyberParks' main objective is to create a research platform on the relationship between Information and Communication Technologies (ICT) and

the production of public open spaces, and their relevance to sustainable urban development. The impact of this relationship will be explored from social, ecological and urban design perspectives." (cyberparks.eu). Augmented reality (mobile) learning may form a potentially significant part of this research.

Smart data is gathered by the WAY-Cyberparks application, in that users running the mobile application on their phones (and actively logged in) can walk through a public space and interact with it through the application. The mobile app persistently collects data about their 'itinerary' that provides researchers with information to develop knowledge on the interactions between users and that space over time. This data can then be used to enhance user experiences when visiting public spaces. This means that over time, a hybrid immersive technology mediated learning experience can utilise what the community of learners has constructed as knowledge to enhance the overall personal experience for each learner. The term *'smart city learning'* for clarification of interpretation may generally refer to the use of these types of large evolving data sets that can be used to inform design, content or interaction, sometimes instantaneously.

Literature

The Smart Learning City

Buchem & Pérez-Sanagustín (2013) offer useful definitions of smart city learning, '… as "open libraries" containing a huge number of resources, such as buildings or artworks, that can be used for learning…' (Giovanella et al., 2013), and '… encompasses formal, informal and mixed learning experiences in urban spaces […] with embedded technologies, supporting new kinds of learning, especially constructing contextual knowledge by moving and operating in an authentic environment'. The authentic environment that learners inhabit impacts on their perceptions of a learning experience, as 'the location from which the individual participant accesses (the) online environment is an integral element in the participant's learning experience', (Jamieson et al., 2002). This has the potential of 'transforming learners into active citizens' (Andone et al., 2014), in a 'participatory urbanism' (Buchem & Pérez-Sanagustín, 2013) of smart city living. Buchem & Pérez-Sanagustín provide some inspiration for measuring impact of an authentic environment on a smart city learning experience with their discussion of blended spaces in the 'movements of everyday life', moving between localness and virtuality, allowing learners to play active roles using digital tools of choice and compiling their own learning experiences (Cochrane, 2014, Bonanno, 2011).

The Interactive System

The interactive system manifested in smart city learning can be considered as a context that provides *interactions* with subject *content* in a particular area of knowledge, through a *digital environment or tool* and involving interpersonal interaction within a *community*. In this context, evaluation of learning experiences is fundamentally about interactions mediated by technology between learners, content and other learners in a networked community. These interactions create a 'seamless' (Sharples et al., 2013) and 'glocal' (Certeau, 1988 in Buchem & Pérez-Sanagustín, Pérez-Sanagustín et al, 2013) learning experience that is enriched by augmented reality (Buchem & Pérez-Sanagustín, 2013) through which learner citizens progress in their awareness, knowledge and competence development. Also described as 'geo-

learning' by Sharples et al., (2013), smart city learning experiences are (predominantly) accessed via smartphones that use location-based technology. These technologies mediate new ways of learning, but also pose challenges. Questions around privacy (Giovanella et al., 2013), user accessibility (Seale & Cooper, 2010) and technology device provision are apparent. Though smartphone ownership continues to increase, especially in Europe (Ericsson Report, 2014), participation may still remain problematic. Historically participation rates have been low for technology mediated learning experiences (Kreijns et al., 2002), and the Internet culture 'Rule of 1%' appears to often still be true (Cook et al., 2015). While use of social media technologies may facilitate easier access (Kent, 2013), participation and engagement of learners may not increase or improve quality of learning (Hubble, 2009) without active moderation (Cook et al., 2015) and social presence of facilitators (Kyei-Blankson et al., 2016). Learning design therefore might need to address these shortcomings.

Measuring Interactions

Methods of data capture and analysis in evaluating smart city learning are complex, as the interactions themselves are multi-modal (face-to-face, virtual, networked) as well as multi-voiced, indicating a move 'toward more dynamic, social alternatives that recognise the situated and intersubjective nature of meaning-making' (Gillespie and Cornish, 2010 in Aveling et al., 2013). Literature provides useful contexts and inspiration, with particular importance given to phenomenography (Marton, 1981) and phenomenography based approaches (Yates et al., 2012), networked learning research (Booth, 2008) and dialogism for concepts around dialogic space (Wegerif & Yang, 2011, Wegerif & Ferreira, 2011) and the *self* identities of individual learners (Wegerif & Yang, 2011, Aveling et al., 2013). Mamaghani et al.'s (2015) analysis of children's drawn images outlines an approach to iterative content analysis using phenomenography variation and outcome space categories which could be applied to smart city learner-generated content experiences iteratively over time or activities. Edwards (2005) study of experiences of web-based information retrieval illustrates an approach to creating phenomenographic outcome spaces relevant to this project, demonstrating multiple layers of experience of the same event, dependent on perspective, prior knowledge and purpose.

Considering interactions with the community, aside from dialogic space and the multi-voiced self and 'other', Pask's (1980) notion of 'the limits of togetherness' might inform some of the analysis of comments amongst groups. This may help to establish and measure conversation (defined by Pask as 'concept-sharing') between members of the learning community, as oppose to 'communication which looks like conversation but is not at all conversational […]', (Pask, 1980). This may be distinct from whether or not knowledge is constructed by the networked community (Siemens, 2004), and Ravenscroft's work (2011) with the Interloc application might offer an alternate way of facilitating knowledge construction, if this is considered a desired outcome of 'effectiveness' for smart city learning. Laurillard's (2002) warnings about conversation of learners in relation to learning content and navigation of the digital tool (p111-112), and not in relation to learning content itself may indicate another layer to measure, as "the material [learners] found was highly relevant […] yet appears to have afforded no productive response of any kind".

Developing the framework

CyberParks Learning at Argotti Gardens, Floriana & Upper Barrakka Gardens, Valletta

Mobile learning located at Argotti Gardens in Floriana will consist of various mobile learning activities (Points of Interest) linked to 'hotpoints' within and in the vicinity of the gardens. Similar procedure will be applied at the Upper Barrakka Gardens including several Points of Interest for the piloting phase through a single hotpoint. Activated by GNSS (Global Navigation Satellite System) via the CyberParks Android mobile application, a user is offered a selection of PoI, which provide predetermined learning content and functionality to contribute with user-learner generated content and commentary. The learning design will offer four learning pathways with associated activities: 'History' (the history of the location), 'Structures' (important structures in the location), 'Processes' (industry, manufacturing or social behaviour and traditions at the location) and finally 'Reflect' (follow-up activities and additional learning opportunities) on completing the hotpoint(s) journey. These pathways provide learning for novice level acquisition of facts and concepts, participatory support and guidance level (for additional problem solving), 'metacognition', and for contributory learning. Evaluation of learning therefore is required to establish the process of learning throughout the experience, for 'what' and 'where' domain content is being learned or engaged with, and then also 'how' it is being learned and to what level. 'Who' and 'why' factors also contribute to both domain content processing as well as additional emotional processing of knowledge and engagement. Learning might be evidenced through the creation of user-learner content or in conversations taking place externally from the CyberParks application, for example using Facebook or Instagram, as well as internally within the CyberParks mobile app.

Technical and learner analytics data such as number of connections between learners, frequency of shared content and sentiment of comments will be measured against stage of learning and learning pathway. Analytics will be available within the CyberParks app and externally using social network analysis techniques. Knowledge construction, concept sharing and dialogue concept expansion in learning experience pathways can be measured using learning outcome criteria developed in conjunction with learning designers, to recognise and record evidence of learning, at which cognitive level, learning stage and pathway. Pérez-Sanagustín et al (2013) describe multi-channel, multi-context, multiple-objective 'glue' services for smart city learning. By measuring interactions in relation to geo cached learning hotpoints in AR learning locations, more might be learned about how 'place and space' affect and impact learning quality and engagement in relation to conceptualising the glue that Pérez-Sanagustín's paper discusses. Noting how learner networks form, and the (multiple) roles that learners may adopt, and evaluating the knowledge being constructed 'in the system' it is potentially possible to evidence how 'connectivist' learning in a smart city hybrid technology mediated environment takes place. This may help to develop useful relationships between learning design and learning experience practice and other stakeholders involved in smart city design and planning such as technical infrastructure specialists, architects and urban community planners.

Anticipated learning experiences at Argotti Gardens and Upper Barrakka Gardens

This paper focuses on user-learner interactions and on the prediction and gathering of data for evaluation of smart city learning, specifically from user-learner sample groups, though other stakeholder sample groups are also involved in smart city learning implementations (learning designers, content creators, subject area specialists and technical application designers and developers). Focusing on mobile learning location-based prototypes being developed and implemented in open/urban spaces located at Upper Barrakka Gardens, Valletta for history and Argotti Gardens, Floriana for botany, learning experiences anticipated will include playful learning, citizen enquiry, seamless learning, geo-learning and crowd learning. The structure of data gathering and analysis would be iterative (over time) and in addition be used to investigate direct or indirect relationship to relevant pedagogical theory and discourse, with special focus on Connectivism.

Evaluating learning in an interactive system - interactions with Content, Digital Tools and Community

In the context of phenomenographical category layers and iteration, and using a dialogic space concept analysis, factors relevant to measuring effectiveness of smart city learning may be derived from data to discover what might be of significance to user-learners. Assessing this learning effectiveness from a variety of user-learner perspectives and analysing relationships with appropriate pedagogy might be then attempted. A first concept of practical techniques using phenomenography is presented here, with ideas for measurement of dialogic space, concept sharing, multi-voiced self and knowledge construction.

The proposed system for evaluation of smart city learning at Upper Barrakka and Argotti Gardens is intended to evaluate experiences for user-learners in relation to principle category interaction variables, in a context of theoretical factors of significance derived from appropriate literature. These category variables - content, digital tools and community – are distinct in their differences, though all are interactions. Consequently the principle category analysis system needs sufficient commonality for correlation of interactions so as to establish meaningful relationships between them. The system proposed here is an iterative approach to gathering sets of data for each principle category that bears relation and connection to each other.

It is anticipated that there will be layers of analysis for these interaction categories, both for factors of interest and for measurement factors, in order to accommodate all layers of interaction. Principal factors of interest would include factors determining learning, Human Computer Interaction, the impact of the authentic space on the augmented reality learning experience and community and social network presence and activity. *Facts determining learning* would evaluate evidence of facts, concepts, problem solving, meta-cognition in interaction behaviour, dialogue and content. The *impact of the authentic space* evaluates evidence of immersive smart urban space experiences (diverse agents for providing, collecting, creating and sharing information), measurement of seamless learning (blending learning with everyday life) and of ‘glocality’ (where local and global co-exist). *Community and social network presence and activity* evaluates the sharing, identity building, community role and collective memory building in any learning communities which may form around the

experiences. Interface design, functionality affordance, perceived usefulness, perceived ease of use and frictionless journeys (user friendly journeys and navigational design) would attempt to be evaluated as *Human Computer Interaction* factors. Layers of analysis also need to take into account multiple literacy modalities to evaluate these factors of interest for the impact of *types* of content on learners*:* multimedia content (audio, video, text, images), domain prescribed content, learner-generated content, and comment interaction content.

By utilising ideas drawn from prior research and discourse, the system proposes to analyse these factors. The following examples provided here draw from Mamaghani et al (2015) for content analysis features, Pask's concept-sharing and Wegerif's Dialogic Space (of addressee, superadressee, infinite other) evaluation for conceptual presence and relevance to establish depth and scope of factors determining learning, for example novice (acquisition), participatory and contributory. 'Multi-voiced self' concepts (Aveling et al., 2014) could evaluate identity variation and role in the network and community. These measurement factors could be applied iteratively into variation categories for evaluating the content, comments and direction of interactions within the principal category variables.

Examples of Interaction Analysis

Examples of interaction analysis outlined here demonstrate how a system of *Interaction Category Variables Analysis* can be used to analyse smart city learning interactions for key factors of interest. Examples given here are for *learner-generated content analysis:* the increase or decrease over learning activity progression demonstrating conceptual assimilation and processing (e.g. Mamaghani et al., 2015), for *community interactions:* the increase or decrease over learning activity progression demonstrating identity (perhaps with alternate 'self voices', Aveling et al., 2014), confidence, dialogic space expansion (Wegerif & Ferreira, 2011) and 'concept-sharing' (Pask, 1980). A third example is provided to begin to measure g*rowing technical efficacy and engagement with digital tool affordances* which could be evaluated for surface and deep interaction functionality efficacy and network participation throughout the learning experience. Looking at *social channel engagement* can further investigate processes of knowledge construction, concept sharing and roles, and consequent evaluation of the significance of social network interactions and functionality at stages of learning and as a whole. Attempting to evaluate a*uthentic environment relevance and engagement in content detail* through evaluating the increase or decrease over learning activity progression, which may be evidenced in comment interactions, sharing and learner-generated content.

Example 1 – Interaction with learner-generated content

Example 1 looks at how learner-generated content interactions may be analysed, either within the CyberParks app or externally in social channels such as Facebook, Twitter or Instagram. Content analysis follows a concept of phenomenographic context in iterative learning stages.

Outcome Spaces (predicted) **External Reflector:** Upload photograph to learning activity		**Theory/Pedagogy** **Specific factors**	**Theory/Pedagogy** **General factors**
Variation Category 1: When it was taken	I took it before I started (the activity) I took it during the activity but before I	Authentic environment, relevance	***Issues/factors to consider:***

	finished I took it after I finished the whole thing I took it on task number or task name Time of day	Knowledge construction Engagement	Participation, confidence in sharing, technical efficacy ***Theoretical discourse that might be found and matched:*** Student as producer Student centered Participatory based activities Mobile 'web 2.0' pedagogies (creative, self-directed)
Variation Category 2: Where it was taken	The location in general The location, at the learning 'stage' or activity area Somewhere else related Somewhere else not related	Authentic environment, relevance Knowledge construction	
Variation Category 3: What is in image and relevance	Building, Tree, Flower, Art, Person, Statue, Animal *Type of shot:* Vista, Close up, detail On or off topic	Authentic environment, relevance Knowledge construction	
Variation Category 4: Who is in the image	Friends Family Strangers Classmates Myself No one	Identity, community identity, multi-voiced identities, role, self efficacy	
Variation Category 5: Emotion of content	Violent Angry Peaceful Happy Beautiful	Emotion of engagement Group identity Self efficacy Role	
Variation Category 6: Why it was taken	I felt like it I wanted to show I was there My friend looked cool I was into it I wanted to remember My mum asked me to It looked really old It was pretty	(Positive and negative) Engagement Learning authenticity Creative approach	

Table 1 Example 1 - Interaction with learning content, predicted outcome spaces, iteration 1

An example of learner-generated content analysis: A study on analysis of children's drawn images with themes of waste recycling (Mamaghani et al., 2015) outlines an approach to iterative content analysis using phenomenography variation and outcome space categories. This approach of multi-stage analysis lends itself to the analysis of learner-generated content in smart city learning, as learning experiences may have stages of learning or multiple tasks or activities which progress the learners understanding of the concepts being discussed. If tasks were designed to request learners to upload content at intervals related to specific activity stages, attempt might be made to understand and measure their levels of cognitive processing, engagement, social learning and dialogic space interaction.

Example 1 may include more granular variation categories for emotion of content and relevance of content to topic, and go on to be developed for analysis of content at stages of learning activity.

Example 2 – Interaction with the community

Example 2 looks at how community comment interactions may be analysed, either within the CyberParks app or externally in social channels such as Facebook, Twitter or Instagram. Comment analysis follows a concept of dialogic space in a phenomenographic context.

Outcome Spaces (predicted) **External Reflector**: Individual posts comment (e.g. about image)		**Theory/Pedagogy** **Specific factors**	**Theory/Pedagogy** **General factors**
Variation Category 1: Who is being addressed (or referenced)	Named Individual Inferred individual The specific group on that thread A generality of assumption Summoning larger perspective	Identity Role Dialogic Space Knowledge construction	***Issues/factors to consider:*** Community, communication confidence, identity, self and other efficacy awareness, critical thinking and awareness, willingness to share knowledge, risk, ***Theoretical discourse that might be found and matched:*** Dialogic space Addressee Superaddressee Infinite Other Multiple identities (p-individuals, multi-voiced selves) Community and communication Concept-sharing Personal Learning Networks Collaborative Learning Communities of Practice Social presence of experts
Variation Category 2: What (comment content)	Concrete concepts Questioned knowledge Trivia Opinions Shared facts	Roles Experts Self efficacy Knowledge construction Concept sharing	
Variation Category 3: Active contributions or questions to discussion	What if we… What are you saying about … What makes you say that? If such and such was the case … In class we did … I remember another similar …	Dialogic space Concept sharing Multi-voiced self P-individual	
Variation Category 4: Tone/emotion positive or constructive	That's so true Hahahaha It's amazing Gorgeous/lovely idea/work/skill Imagine if …	Emotion of engagement (sentiment) Empathy Conceptual assimilation Knowledge construction Concept sharing Authentic learning Confidence and sociability Purpose /understanding	
Variation Category 5: Tone/emotion negative or destructive	That's rubbish I don't believe that You just made that up Negative memes		
Variation Category 6: Tone/emotion neutral	I have no clue what you're talking about No idea Off topic		

Table 2 Example 2 - Interaction in the community (comments), predicted outcome spaces, iteration 1

An example of dialogic space analysis: If interactions in the community were grouped into types of statements, association could be recognised and grouped with addressee (direct), superaddressee (the 'third perspective'), and infinite other (infinite perspectives appearing from those previously referenced by self or group). These could then be counted and analysed iteratively to establish when and where expansion of dialogic space was being evidenced in relation to learning task, activity or stage in pathway. Wegerif & Ferreira (2011) indicate a system of dialogic space that could be developed and implemented, with "Students unpack(ing) opportunities collaboratively looking for attributes and relationships among concepts and new ideas, […] to organize the information". Categories can then trace the development of the
dialogic space for evidence of expansion and reflection.

Example 2 would also include *practical* 'when and where' variation categories to evaluate stages of learning in relation to the authentic environment. Affective (emotion) categories here are more defined than Example 1 as may be expected to be more evident in relation to learning experience perceptions.

Example 3 – Interaction with a digital tool

Example 3 looks at how user-learner interactions may be analysed for the technology mediation of learning interactions, predominantly within the CyberParks app though also externally in social channels such as Facebook, Twitter or Instagram.

User-learner behaviour analysis follows a concept of usability techniques, and also phenomenographic context in relation to learning experience interactions.

Outcome Spaces (predicted) **External Reflector**: Register on the WAY-Cyberparks application		**Theory/Pedagogy** **Specific factors**	**Theory/Pedagogy** **General factors**
Variation Category 1: Negative Registration experiences	I hate doing this kind of thing It was too fussy I couldn't use Facebook I don't use social media anyway It didn't work I don't give my email to anyone *Other negatives*	Sociability Self efficacy Digital literacy Perceived usefulness Perceived ease of use Privacy Confidence	***Issues/factors to consider:*** personal identity, privacy, confidence, trust, sociability, consent, purpose, engagement ***Theoretical discourse that might be found and matched:*** Identity, trust, perceived usefulness, curiosity, discovery, sociability online
Variation Category 2: Positive Registration experiences	It was ok I had no problem Mum said it was easy I think its fun I used a mad username I thought I might use it again so it was worth the hassle *Other positives*	Sociability Self efficacy Digital literacy Perceived usefulness Perceived ease of use Privacy Confidence Curiosity	
Variation Category 3: Neutral Registration experiences	Not sure Don't know Didn't think about it *shrugs shoulders* Mum did it *Other neutrals*	Sociability Self efficacy Digital literacy Perceived usefulness Perceived ease of use Privacy Confidence	

Table 3 Example 3 - Interaction with digital tool predicted outcome spaces

An example of digital tool interaction analysis: Looking at a number of factors both those integral to learning interaction affordance and also those of human computer interaction and interaction (interface) design. With a mixed approach to analysis using pedagogical factors and usability heuristics some understanding might be derived as to the role of technology mediation and affordance in relation to learning experiences at surface and deep level.

Example 3 might be developed to include other categories for technical self-efficacy (surface and deep structure of the tool for information design and pedagogical features) and emotions about technology. Surface structure interactions refer to interface functional activity, navigation of content and system understanding or technical manipulation of content (creating, editing or sharing content). Deep structure technical interactions may be a measurement of how many interactions a learner makes with asynchronous community members, or connects and interacts with an external expert about domain content or query problem solving.

Participant Second Analysis

A set of analysis could be utilised, potentially known as 'Participant Second Analysis' where it may be possible to see how participants themselves analyse and interpret interactions. Discussions and category analysis using card-sorting techniques might be particularly

enlightening for learner-generated content interactions and community interactions, and could be carried out after a learning activity or during the event. This would elicit think-aloud or focus group data, from participant groups or with individuals.

Participant Second Analysis for learner-generated content

Potential questions for learner-generated content, looking at content shared in social media channels or in the WAY-Cyberparks app, individuals or groups could be asked to talk about the content.

Potential Questions about photograph or video content generated by the learner (learner-generated content)	**Theory/Pedagogy Specific factors**	**Theory/Pedagogy General factors**
• Where was it taken? Describe to me in your own words • Location and stage in learning activity (factual) • What does it represent? Is this image important to you? In what ways? • What is in the photo? – Describe the scene in your own words: *(A building, view, landscape, close up detail, atmosphere)* – • Do you like it? If so, what made you like it? If not, why not? • People you know – who are they? Is it important they are included? Why? • People you don't know – why did you take it with them in it? • Yourself – why did you take a selfie? What does it represent or mean to you? • Why was it taken, what inspired the action? • Did you share it? Where, with whom? Why did you share it?	Knowledge construction Authentic environment situated learning Meaning making Concept-sharing Concept assimilation Multiple intelligences	Student directed learning Student participation Creative pedagogy Personal learning Learner Agency and autonomy

Table 4 Examining learner-generated content interactions with participants afterwards (*Participant Second Analysis)*

These questions and similar ones in semi-scripted interview or focus group discussion can expand a dialogic space for the learner(s) to tell us about what they experience in a learner-generated content interaction. We are then able to deduce more about levels of concept construction and assimilation, identity development and critical analysis skills.

Participant Second Analysis for community interactions

Potential questions about comments made by learners in networked community scenarios, looking at comment threads made in social media channels or in the WAY-Cyberparks app, individuals or groups could be asked to talk about what was going on in the thread.

Potential questions about comments made by learners in networked community scenarios.	**Theory/Pedagogy Specific factors**	**Theory/Pedagogy General factors**
• Who are you talking to there? • Why did you say that at that point? • Did you mean you agree with that statement, or disagree? • Did you get the feeling people liked you in the group? • Did you get the feeling people disliked you in the group? • Did you feel that comment was bossy or aggressive? • Did you want to say more there, and held back? • Did you think that some of the people chatting were very knowledgeable? • Did you feel shy? Why? • Did you feel like it was fun or interesting? Why? • Did you think this was a boring thread? • Did anyone talk about (insert factual or relevant info on topic)? • Was anyone trolling or being annoying? • Why did you start posting in the thread?	Multi-voiced self Identity making Roles in community and network (novice/expert) Confidence Self efficacy Meaning making Concept sharing Dialogic space expansion	Student directed learning Student participation Creative pedagogy Personal learning Learner Agency and autonomy

Table 5 Examining interactions in the community (comments), with participants afterwards (*Participant Second Analysis)*

These and similar probing questions could shed light on how learners feel when interacting in comment threads, how they might be developing conceptual understanding, how the process promotes or hinders this, expands and develops dialogic space and can perhaps be measured to create variation categories using some criteria discussed in Wegerif & Ferreira (2011).

Conclusions

Measuring the effectiveness of learning without resorting to assessment is a challenge in any conventional classroom. To attempt this with additional challenges and variables posed by physical space and technology mediation impact further complicates analysis methodology. However, by looking at the interactions first, for authentic space context, community concept sharing and human computer interaction factors, insight can be gained. Through diligent analysis of findings a contribution can potentially be made to urban planning as well as for technical application and learning design. A question persists: is interactivity engagement a reliable measure of learning effectiveness? The rate of active learner participation may not reflect levels of engagement or cognitive processing (Hubble, 2009). Data gathered from interactive geo learning experiences located in Valletta may yield findings to shed further light and contribute to greater understanding in this particular discourse if this question is acknowledged.

Overall, creating effective learning design pedagogy for smart city learning, with its multiple strand stakeholders, considerations and analysis layers is an evolving process to be established by ongoing research, discourse and interpretation. Many ethical considerations - not discussed in this paper - are potentially problematic for smart city learning, for data privacy, data anonymity, intellectual property rights, legal aspects of terms of use, accessibility and digital literacy amongst others. By gaining insight into levels of usefulness, engagement and learning quality these separate challenges might have a wider knowledge base on which to form new approaches in some of these areas.

References

Amershi, S, Arksey, N, Carenini, G, Conati, C, Mackworth, A, Maclaren, H, Poole, D, 2005, Designing CIspace: Pedagogy and Usability in a Learning Environment for AI, ITiCSE ’05, June 27-29, 2005, Monte de Caparica, Portugal, (ACM)

Andone, D, Holotescu, C & Grosseck, G, 2014, ‘Learning Communities in Smart Cities, Case Studies’, IEEE 978-1-4799-5739-2/14/

Aveling, E, Gillespie, A, Cornish, F, 2014, ‘A qualitative method for analysing multivoicedness’, Qualitative Research 1-18, 2014, Sage Publications DOI: 10.1177/1468794114557991

Bonanno, P, 2011, ‘A Process-oriented pedagogy for Ubiquitous Learning’, in ‘Ubiquitous learning: strategies for pedagogy, course design, and technology’, ed. Kidd, T & Chan, I, Information Age Pub

Bonanno, P, 2014, Designing Learning in Social On-line Learning Environments: A Process-oriented Approach, in Mallia, G.: The Social Classroom: Integrating Social Network Use in Education, IGI Global Publishing. (Pg 40-61)

Booth, S, 2008, ‘Researching Learning in Networked Learning – Phenomenography and Variation theory as empirical and theoretical approaches’, Proceedings of the Sixth International Conference on Networked Learning, Networked Learning 2008, Greece

Boyd, G, 1993, ‘Educating Symbiotic P-Individuals through Multi-level Conversations’, Systems Research Vol. 10, No. 3, pp. 113-128

Buchem, I and Pérez-Sanagustín, M, 2013, 'Personal Learning Environments in Smart Cities: Current Approaches and Future Scenarios', eLearning Papers no. 35, ISSN: 1887-1542
Cochrane, T, 2014, Mobile Social Media as a Catalyst for Pedagogical Change, EdMedia 2014 - Tampere, Finland, June 23-26, 2014 (preview paper)
Cook, J, Lander, R and Flaxton, T, 2015, 'The zone of possibility in citizen led hybrid cities. In: Workshop on Smart Learning Ecosystems in Smart Regions and Cities', Toledo, Spain, 15 September 2015.
Edwards, S, 2005, Panning for Gold: Influencing the experience of web-based information searching, PhD thesis, School of Information Systems, Faculty of Information Technology, Queensland University of Technology
Ericsson (Europe) Mobility Report, Appendix, 2014, Ericsson SE-126 25 Stockholm, Sweden, EAB 14:018052
Giovanella, C, 2013, 'International Observatory on Smart City Learning, Problems Addressed', retrieved from http://www.mifav.uniroma2.it/inevent/events/sclo/index.php?s=166&a=300, last viewed 12/2/16
Giovanella, C, Martens, A & Zualkernan, I, 2016, Grand Challenge Problem 1: People Centered Smart "Cities" Through Smart City Learning, in J. Eberle et al. (eds.), Grand Challenge Problems in Technology-Enhanced Learning II: MOOCs and Beyond, SpringerBriefs in Education, DOI 10.1007/978-3-319-12562-6_2
Hubble, D, 2009, COLMSCT Final Report 'Improving student participation in e-learning activities', UK Open University
Kreijns, K, Kirschner, P, Jochems, W, 2002, 'The Sociability of Computer-Supported Collaborative Learning Environments', Educational Technology & Society 5 (1) 2002 ISSN 1436-4522
Kyei-Blankson, L, Ntuli, E & Heather Donnelly, D, 2016, 'Establishing the Importance of Interaction and Presence to Student Learning in Online Environments', World Journal of Educational Research ISSN 2375-9771 (Print) ISSN 2333-5998 (Online) Vol. 3, No. 1, 2016
Laurillard, D, 2002, Rethinking University Teaching, a conversational framework for the effective use of learning technologies, 2nd edition. Routledge Falmer
Mamaghani, N, Mostowfi, S & Khorram, M, 2015, 'Using DAST-C and Phenomenography as a Tool for Evaluating Children's Experience', American Journal of Educational Research, Vol. 3, No. 11, 2015, pp 1337-1345, retrieved from http://pubs.sciepub.com/education/3/11/1/index.html, last viewed 6/2/16
Marton, F, 1981, Phenomenography - Describing Conceptions of the World around us, Instructional Science 10.p 177-200
Mor, Y, Cook, J, Treasure-Jones, T, Elferink, R, Holley, D, Griffin, J, 2015, Patterns of Practice and Design: Towards an Agile Methodology for Educational Design Research, Chapter in Design for Teaching and Learning in a Networked World, Volume 9307 of the series Lecture Notes in Computer Science pp 605-608
Pask, G, 1980, 'The Limits of Togetherness', Invited paper, Information Processing 80, S.H. Lavington (ed.) Norman-Holland Publishing Company
Pérez-Sanagustín, M, Buchem, I & Kloos, CD, 2013, Multi-channel, multi-objective, multi-context services: The glue of the smart cities learning ecosystem, Interaction Design and Architecture(s) Journal - IxD&A, N. 17, 2013, pp. 43-52
Ravenscroft, A, 2011, 'Dialogue and Connectivism: A New Approach to Understanding and Promoting Dialogue-Rich Networked Learning', International Review of Research in Open and Distance Learning, Vol. 12.3
Rogers, C, 1951, 'Client-centered therapy: Its current practice implications, and theory', Boston, New York, Chicago, Houghton Mifflin
Seale, J & Cooper, M, 2010, E-learning and accessibility: An exploration of the potential role of generic pedagogical tools, Computers & Education 54 (2010) 1107–1116
Sharples, M., McAndrew, P., Weller, M., Ferguson, R., FitzGerald, E., Hirst, T., and Gaved, M. (2013). Innovating Pedagogy 2013: Open University Innovation Report 2. Milton Keynes: The Open University.

Siemens, G, 2005, 'Connectivism: Learning as Network-Creation', ElearnSpace
Siemens, G, 2004, 'Connectivism: A Learning Theory for the Digital Age', ElearnSpace
WAY-Cyberparks application, available at http://cyberparks-project.eu/app, part of a COST (European Cooperation in Science and Technology) initiative, supported by the EU Framework Programme Horizon 2020
Wegerif, R & Ferreira, DJ, 2011, Dialogic Framework for Creative and Collaborative Problem-solving, Computer-Supported Collaborative Learning Conference July 4-8, 2011, Hong Kong, China, Vol 2, Short Papers & Posters, p888
Wegerif, R, and Yang, Y, 2011, 'Technology and Dialogic Space: Lessons from History and from the 'Argunaut' and 'Metafora' Projects', 9th International Computer-Supported Collaborative Learning Conference July 4-8, 2011, Hong Kong, China, Vol 2, Short Papers & Posters, p312
Yates, C, Partridge, H & Bruce, C, 2012, Exploring information experiences through phenomenography, Library and Information Research Volume 36 Number 11