Emergent Play and Games when Combining Ambient Intelligence with Wireless Grids[1]

H. Patricia McKenna[a,*]
[a]*AmbientEASE, #541, 185-911 Yates St., Victoria, BC, V8V 4Y9, Canada*

Abstract. Based on research with WeJay, an early pre-standards wireless grid social radio tool, this paper focuses on emergent interactions of a playful nature and instances of thoughtful, serious game conceptualization. Responding to case study findings emerging from the study of ambient intelligence (AmI) with wireless grids among faculty and students, the playful and gaming dimensions of AmI-infused wireless grid applications are advanced, extending earlier research. Implications for research and practice settings are provided together with a research agenda.

Keywords: Ambient intelligence (AmI), emergent interactions, emergent learning, wireless grids

1. Introduction

This paper draws upon earlier wireless grids research with collaborative learning environments [1]; more recent research on ambient intelligence (AmI) with wireless grids [2], [3]; and emergent communities of play [4] in extending the notions of playful interactions and serious games. The importance of interactions [1] has been developed in relation to the use of wireless grids for learning, together with gaming [1] and the value of game theoretics [5].

WeJay social radio is the first pre-standards wireless grid application to emerge from the Wireless Grids Innovation Testbed (WiGiT) Lab. Beta testing of WeJay in a study of ambient intelligence (AmI) with wireless grids served to confirm the presence and feasibility of embedded awareness features in wireless grid tools [2], [3]. Additionally, the beta testing use experience provided recommendations for enhanced forms of smartness and revealed insights into the nature of playful interactions and gaming with wireless grid tools. It is the nature and implications of these research study findings together with the emergent insights around ambient-aware wireless grids that will be explored, conceptualized, and theorized more fully in this paper.

1.1. Ambient Intelligence and Wireless Grids

Wireless grids are defined by Wireless Grids Innovation Testbed (WiGiT) researchers as: "an emerging form of network for sharing resources, creating resources, facilitating connections across devices (smartphones, sensors, etc.) and enabling, ad hoc interactions" [5]. Recent WiGiT standards refer to wireless grids as: "A human centric open access gateway to shared resources for mobile and wireless electronic devices interconnecting at least one device to at least one other device or resource. A device can establish a grid and become a member of one or more wireless grids." [6]. While wireless grids were deployed by Aruba Networks [7] in 2004, it is important to note the existence of different understandings of the wireless grid concept. McKnight [8] claims that, for Aruba, wireless grid "pertains to an array of wifi routers managed as a grid" with a "focus close to the physical network." For WiGiT researchers, McKnight indicates that the wireless grid concept is "abstracted away to a virtual space of users, machines and heterogeneous networks."

Ambient intelligence (AmI) is defined as "the embedding and integrating, on a mass scale, of technologies that are sensitive and responsive to humans

[1] Author affiliation: Wireless Grids Innovation Testbed (WiGiT) Lab, School of Information Studies, Syracuse University.
[*] Corresponding author E-mail: hpmckenn@syr.edu.

in everyday environments in increasingly invisible and unobtrusive ways" [9]. In the context of human-centered computing (HCC), Sebe [10], drawing upon earlier work by Canny [11], refers to computing as "infrastructure around human activity" which would seem to align with the articulation of wireless grids by WiGiT researchers as "an emerging infrastructure that will fundamentally change the way we think about and use computing" [1], [12].

Wireless grids have been theorized for use with emergency response [12], learning in collaborative educational environments [1], health [13], energy [14], and cloud computing [15].

The two key questions of interest in this paper are:

1. What is the nature of *playful interactions* within ambient-aware wireless grids?

2. What form does *serious gaming* take in ambient-aware wireless grid environments?

What follows is a review of the literature on playful interactions and serious gaming generally and more particularly, in relation to ambient intelligence and wireless grid environments.

1.2. Literature Review

An overview is provided of the research literature on playful interactions, followed by a look at the serious gaming literature, and then both play and gaming are considered in relation to technology-pervasive learning environments, in the context of ambient intelligence (AmI) with wireless grids.

1.2.1. Playful Interactions

The importance of play in the research literature emerges as a possibly contested area of research, referred to by Brown and Vaughan as "a hugely complex and controversial subject" [16]. Play has been theorized from a variety of perspectives with Wilson [17] claiming that "no behavioral concept has proved more ill-defined, elusive, controversial and even unfashionable than play". From an evolutionary biology perspective, Spencer [18] argued that in the absence of a persistent struggle for survival, play served to release excess energy as in, 'unemployed energy', enabling the imitation of 'serious' activities. Spencer [19] also argued for the relevance of play and enjoyment to learning. Groos [20] proposed a theory of play conceptualized from a range of perspectives –"'physiology, biology, and psychology, and a more definitely aesthetic, sociological, and pedagogical view." In relation to the physiological aspect of the persistence of play, Groos noted the 'circular reaction' and the 'trance condition'. In the absence of 'serious exercise', Groos makes reference to the practice and preparation aspects of play.

Proponents of play, including evolutionary biologists [21] and experimental neuroscientists [21], claim purposeful and beneficial outcomes for playful interactions. For example, Bekoff, an ecology and evolutionary biologist, describes play as a kaleidoscope of behaviors. Bekoff, together with Spinka and Newberry [22] proposed "that play functions to increase the versatility of movements and the ability to recover from sudden shocks" as well as "to enhance the ability of animals to cope emotionally with unexpected stressful situations". Bekoff claimed that animal research findings around play are applicable to humans [21].

Bekoff and Byers [23] proposed a definition of play as "all motor activity performed postnatally that *appears* to be purposeless, in which motor patterns from other contexts may often be used in modified forms and atlered temporal sequencing". Regarding playful interaction, Bekoff and Byers [23] added that, "If the activity is directed toward another living being it is called social play." Problems were acknowledged with the play definition, in that the definition could encompass 'repetitive pacing' behaviors which are generally not considered to be play and what constitutes or 'appears' to be purposeless.

Where play was theorized to be a type of preparation or rehearsal [21], Byers and Walker [24] probed further, in view of the expenditure of energy involved with play and the risk potential. Seeking an alternative understanding, Byers and Walker "propose that play may not be motor training in the broad sense, but rather it may be behavior designed to influence specific types of development."

Brown and Vaughn [16] note that Diamond [25] used the term 'enrichment' in conducting experiments which "are among the most well-established research findings showing that play is crucial to healthy brain development." In order to be taken seriously as a scientist, Diamond claims that she "did avoid the words 'toys' and 'play'".

Reviewing *Evolutionary Playwork* [21], Bekoff cites the intention of Hughes "to re-emphasize that the growing body of scientific evidence confirming a direct relationship between play, evolution and brain growth" be understood "as comprehensive support for deep biological processes – expressed through mechanisms like adaptation, flexibility, calibration

and the different play types" critical to survival. As such, Spinka, Newberry and Bekoff [22] argue for play as "training for the unexpected."

According to Brown and Vaughan [16], "Neuroscientists, developmental biologists, psychologists, social scientists, and researchers" now "know that play is a profound biological process" that "fosters empathy and makes possible complex social groups." Further, "play lies at the core of creativity and innovation" claims Brown and Vaughan, adding that what was once thought to be the 'apparent purposelessness' of play is actually a key defining aspect of play. Brown and Vaughan note the pervasiveness of play in nature, "human culture and across the evolutionary spectrum." In considering the purpose and utility of play, Brown and Vaughan include the various ideas advanced through a range of theories including:

- Play as "practice for skills needed in the future" (e.g., emotional intelligence);
- Play "allows 'pretend' rehearsal for the challenges and ambiguities of life" and as such, "Playful interaction allows a penalty-free rehearsal of the normal give-and-take necessary in social groups";
- The cognitive value of play drawing on the work of Diamond [25], whereby, "in playing, we create imaginative new cognitive combinations" and "in creating those novel combinations, we find what works."

Sortino and Wiltse promote the *playful inquiry model* [26] which they claim "leverages the benefits of playfulness to unlock our natural creativity and expand our capacity to solve problems."

Brown and Vaughan [16] argue for the importance of play, citing Sheets-Johnstone [27] on "the origins of 'knowing' coming from body movement, with play as a major teacher." Sutton-Smith, in the *Ambiguity of play* [28] welcomes the complex and paradoxical nature and interpretations of the 'playful concepts'. Sturm and Sebouten [29] note that traditionally, play has been confined within a fixed 'time and place' or 'magic circle', citing Huizinga [30] and Caillois [31].

The work of many researchers in the domain of play and playful interactions is emerging with renewed vigor, contributing increased insight and value. More recently Bekoff articulated concern with "the union of play with emergent morality" [32]. In the context of technology pervasive environments it is worth noting Hollander's [33] articulation of ethics and moral imperatives drawing on the Association of Computing (ACM) code of ethics, specifically the commitment to "contribute to society and human well-being" in keeping with the mission of the WI-GIT Lab and wireless grids researchers and the focus of Human Centered Computing (HCC) researchers in the ambient intelligence (AmI) domain.

Sturm and Sebouten [29] argue that the notion of pervasive play is not new, claiming that "Traces of pervasive playfulness can probably be found in all civilizations", adding that "Mysteries, scavenger hunts, and ludic pranks have long been a part of modern society." Technology-pervasive environments including "new media, social networks, modern technology and (social) interaction" enable digital play, allowing for greater integration "in a spatial, temporal and social sense" [34] as articulated by Montola, Stenros, and Waern in *Pervasive games*, highlighting "experiences on the boundary between life and play.

1.2.2. Serious Games

An overview of the origins of the serious gaming concept is provided by Djaouti, Alvarez, Jessel and Rampnoux [35]. Djaouti et al. use Michael and Chen's [36] definition of the concept to denote "games that do not have entertainment, enjoyment or fun as their primary purpose." Similarly, the European Union [37] employs the definition provided by Michel and Chen's [36]: "A serious game is a game in which education (in its various forms) is the primary goal, rather than entertainment." The European Union (EU) draws on the work of Zyda [38] to further refine the definition of serious game to denote: "a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives." Zyda notes that "serious games use pedagogy to infuse instruction into the game play experience." For the EU, Zyda's work points to the importance of simulation in relation to serious games. Zyda articulates the importance of creating a science for games and developed a three-part games research agenda focused upon "infrastructure, cognitive game design, and immersion" able to support "innovation and increased complexity" as well as affective computing.

Focusing on transformative games, play, and learning, Nicholson identifies a theoretical framework [39] and strategies [40] for meaningful gamification. Citing Deterding, Khaled, and Dixon [41], Nicholson describes gamification as "the use of game elements in non-game contexts." Nicholson indicates that 'games for change', as in "games that are de-

signed to make a difference", was used instead of the serious game concept, at the 2012 Games for Change conference. However, citing Schell [42] who advances the concept of *transformative game*, Nicholson states that: "The advantage of this term is that it describes what impact the game has from the perspective of the player, instead of presenting the goal of the game (games for change) or the context of the game (serious games)." Meaningful gamification is participant-focused, engages users in real-world activity, incorporates a playful design, is mindful of internal motivation in support of engagement, and encourages transformative learning. As such, ludic learning spaces in support of meaningful gamification models as articulated by Nicholson "allow participants the freedom to choose how to engage, the tools to create their own gamification elements, and the ability to build social connections with other users based upon common interests."

It is worth noting that the Serious Play Conference 2013 [43], highlighting the importance of serious play across a broad range of sectors (e.g., education, human resources, corporate training, health care, military or government, or manage the education program at a museum) features what is claimed to be "the first major study of the impact/future of non-entertainment games."

1.2.3. Serious Play and Games with Ambient-Aware Wireless Grids

A human-centered computing agenda in relation to ambient intelligence was articulated by Sebe [10] and by Sears, Lazar, Ozok, and Meiselwitz [44]. More recently an HCC agenda was reorganized within the context of Intelligent Information Systems (IIS) by the National Science Foundation NSF [45].

Bekker, Sturm, and Eggen [46] describe three design values in support of the design of playful interactions – motivating feedback; open-ended play; and social interaction patterns. Using intelligent objects, creativity affordances (e.g., collaboration, negotiation of game aspects, and socio-physical interactivity) are enabled through social interactions together with the potential for emergent behavior.

Sturm and Sebouten [29] articulate the nature of ambient gaming and play emerging from an ambient gaming workshop in 2011. Ambient games and play are taken to mean "playful activities that are seamlessly integrated within our daily lives in such a way that the boundaries between other activities and play disappear or blur."As such, virtual and real worlds blend, contributing to mixed reality environments. Multiple pervasive devices support ambient games and play interactions which are said to possibly be more natural and motivational. However, challenges of a technological, social, and ethical nature are identified. Citing Aarts and Marzano [47], Sturm and Sebouten [29] claim that ambient games and play "incorporate ambient intelligent characteristics which means being surrounded by 'smartness'."

Research by McKenzie [48] suggests the importance of 'gamification' as a consideration in the diffusion, adoption, and use of applications containing location-awareness, involving "an aspect of *game play*". Cramer, Ahmet, Rost, and Holmquist [49] (2011) express concern that the gamification aspect of location-sharing applications may contribute to 'social conflicts', indicating the importance of social context and other associated motivations.

Sturm and Sebouten [29] argue that "ambient gaming and play change the traditional notion of 'game', as governed by a well-defined set of rules, impenetrable to our everday interactions, and bounded in terms of time, space, and participation, by expanding it in spatial temporal and social sense". Drawing on the work of Montola, Stenros, and Waern [34], Sturm and Sebouten [29] contend that "Space, players, onlookers, and passers-by may move in and out of the ambient play space and influence what happens even unaware." As such, "Playful interactions in ambient play spaces are thus likely to lead to more social involvement, as compared with traditional, bounded play environments."

Following from the introductory background provided together with the literature review, the theoretical perspective will now be presented together with the methods used to gather and analyze data. Examples of emergent interactions in the form of playful interactions and serious games are provided. A discussion and evaluation of emergent findings and insights is provided followed by conclusions and implications for research and practice.

2. Methodology and Theoretical Perspective

Using a case study approach, incorporating a mix of quantitative and qualitative methods, a pre-standards social radio tool was beta tested among faculty and students in a virtual distributed environment. WeJay, the early stage wireless grid edgeware application under investigation, supported a range of functionalities including interactivity, collaboration, adaptability, sharing, and presence awareness. Se-

lected students and faculty in a university context who were knowledgeable about wireless grids or social media, or a combination of the two, participated in the study.

The study was focused on:

- The experience of faculty and students during the deployment and first use of, or exposure to, the social radio tool;
- Whether the tool would be potentially transformative and disruptive as theorized;
- Several research propositions related to the fostering of creativity, innovation and novel and unexpected uses on the one hand and the theorized relationship between AmI and wireless grids on the other [2].

2.1. Approach

A single case study approach was used in support of the contemporary nature of the issues under study, as in, the experience of faculty and students with emerging intelligent information technologies for education. Upon signing up for the research study, participants were instructed to download and install the WeJay tool; create a radio station; develop a radio show with their choice of content; host or cohost the show with one or more individuals; and live-stream the show for shared listening within WeJay, with Facebook friends, and with others who wished to tune-in to the Weheartradio broadcast over the Internet [2].

An unstructured approach was employed during the four month duration of the largely exploratory study. Participants received minimal guidance, supports, and influences during the study while maximal play, interaction, and exploration was encouraged.

Data was collected in a variety of ways including:

1. *activity data* – the tracking of real-time information pertaining to tool use
2. *interviews* – individual protocol-based interviews were conducted with participants to discuss their experience
3. *focus groups* – group protocol-based focus groups were conducted with participants to discuss their experience
4. *survey* – a survey instrument was developed and administered based on interview and focus group data

Quantitative data derived from tool use activity data was enhanced by qualitative data gathered systematically through interviews and focus groups. A combination of closed and open-ended survey questions contributed further to the quantitative and qualitative dataset, respectively. Interviews and focus groups allowed for the engaging of participants in conversations about smartness and ambient intelligent information systems in wireless grid and social media environments. The interview and focus group protocols were pretested, revised, and approved prior to use as was the survey instrument.

A combination of deductive and inductive approaches used during data analysis contributed to the development of insights. Specifically, content analysis was employed for the inductive gathering of emergent information from the two focus groups, the twenty-two interviews and the open-ended survey data. During content analysis, coding of data was conducted deductively based on the theoretical framework and the three key constructs – creativity, innovation, and context awareness – guiding the research propositions. Based on the emergence of codes, a coding glossary was developed supporting the use of explanation building and pattern matching, an analytic technique used with case studies [50]. A second coder enabled the testing and refinement of coding techniques and practices and the provision of coding. In total, 1000 text segment were coded separately by the first and second coders and analyzed for inter-coder reliability where 91%-94% accuracy was achieved.

The use of descriptive statistics on the relatively small sample size (n=34) enabled the presentation of analysis and findings. Complete and valid survey responses were provided from n=20. Triangulation [50], [51] was conducted in a variety of ways contributing rigor to the findings, as follows:

1. *data triangulation* – use of multiple sources of evidence
2. *methodological triangulation* – use of four data collection methods representing both quantitative and qualitative data
3. *investigator triangulation* – engagement of multiple data coders

Interpretation of findings was based on several criteria, including:

1. *ratio of participants who* – developed new ideas; implemented one or more ideas; found the idea to be implementable; found new use to be possible by context
2. *interaction frequency*

3. *extent of emergent elements* – behaviors, attitudes, patterns, and activities

Research study constructs and measures were operationalized with close adherence to the research study questions and propositions in relation to the theoretical framework.

2.2. Theory

Emergence theory, encompassing emergent properties, structures/processes, patterns, and attitudes/behaviors was used to provide the theoretical framework for the study from a social and socio-technical perspective. Emergence theory was found to be particularly amenable to the adaptive, uncertain, and other elements characterizing AmI and wireless grid environments [2], [3]. The use of emergence theory is prevalent in gaming and play communities [4] and the theory is said to pertain to that which is in-the-making and to novelty [52]. The conceptual framework guiding the study is illustrated in Fig. 1 providing an overview of the research study design.

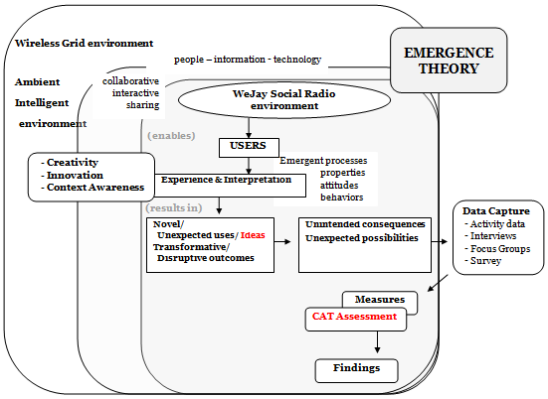

Fig. 1. Conceptual Framework: AmI with Wireless Grids (WeJay)

From this model, key elements of the study are highlighted:

1. *Wireless grid environment* as the underlying platform and infrastructure for people, information, and technology
2. *AmI environment* as a space supportive of collaboration, interaction, and sharing, under study in relation to emerging wireless grid tools
3. *WeJay Social Radio* beta trial environment
4. *Emergence theory* as the theoretical perspective through which to investigate use experiences and interpretations for use
5. *Creativity*, *innovation*, and *context awareness* constructs enabling study of the research propositions and the emergent interactions
6. *Outcomes* emerging from an analysis of data collected using multiple quantitative and qualitative methods – novel/unexpected uses/ ideas; transformative/disruptive; unintended consequences and unexpected possibilities
7. *Measures* supported or predicted in the literature to assess and inform findings

Through the analysis of data pertaining to social interactions, insight into emergent behaviors and playful interactions is gained. It is worth noting Johnson's [53] description of *emergent behaviors* which: "like games, are all about living within the boundaries defined by rules, but also using that space to create something greater than the sum of its parts."

What follows is a reporting of emergent interactions pertaining to playful interactions and serious games using an early stage tool representing an ambient intelligence with wireless grids environment.

3. Emergent Interactions: Learn-Play-Games

During the research study, two individuals separately developed ideas for games with a learning component which they began to implement and test but did not complete during the beta trial period. Lack of completion was due in part to the state of readiness of the tool. Other participants generated opportunities and ideas for playful interactions while a number of participants conceptualized more serious implementations of the tool. For the purposes of this paper, these ideas and interpretations for use of the WeJay product are identified as: game play and learning, more than just playful interactions, and serious applications.

3.1. Game Play and Learning

The first playful interaction and gaming idea for WeJay involved the conceptualization of a mobile learning and play type of game in form of a scavenger hunt designed for use in an urban environment. The participant described the function of creating radio stations as a tool to develop a game where the radio station attributes were equated to clues needed

for the scavenger hunt. While this activity was playful with the intent to entertain, the participant also found the exercise to be engaging and motivating particularly during the development of the game strategy component. Further, the mobility dimension of the game would enable the element of discovery during play.

The second playful interaction and gaming idea for WeJay involved the crafting of a broadcast entitled *Sounds of Science, Ears of Engineers*. Described by the participant/designer, this idea was supposed to be similar to a game where, in a circle of five participants, one person would provide a sound file of some sounds in nature such as the rustling of leaves. The other people in the circle would then comb through their own sound files to find some technology related to that sound. In this case, a leaf blower could be an example. As such, according to the participant/designer, this game proposed an opportunity "for people to open to more audio channels for learning, rather than just visual or kinesthetic."

3.2. More Than Just Playful Interactions

Unexpected learning, monetization, and other dimensions emerged during playful interactions and conversations on tool use and interpretations of tool use and potential.

One participant described the development of a news and science and engineering broadcast in the form of informative podcasts interlaced between sound tracks of music. Although this idea is not a new one, the participant was motivated to experiment and develop this type of mixed media broadcast for an emerging technology environment for educational purposes.

Use of the tool for creation of a radio show, when shared through Facebook, resulted in a job offer to develop and host a local radio station. Sharing of radio shows resulted in a variety of outcomes including the broadening of one's music awareness. This increased awareness resulted in one instance of the decision to purchase the music enjoyed during the listening experience.

In some instances participants enjoyed the experience of listening to broadcasts created by others and learning about potential uses and interpretations for use. Others enjoyed the shared group listening experience and chatted about the content during the broadcast. One participant encouraged a friend and colleague to sign up for the study and explore the tool while another participant co-created and co-hosted a show with his mother who was living in another location. This participant also used Twitter to comment on the beta trial use experience and engaged in a conversation around ways in which the WeJay tool could be used in a course in which his father was enrolled.

Some participants attempted to share and engage with friends and colleagues in other countries (e.g., Africa, Asia) although tool readiness was limited to the United States and the United Kingdom. Possibilities were elucidated for hacking the system by one participant while privacy and security concerns were expressed by others. Participants were paradoxically knowledgeable about embedded awareness in social media and other systems on the one hand and unaware on the other hand. In the latter case, participants indicated that various types of system awareness (e.g., presence, location, interests, etc.) is expected and as such, is taken for granted. Participants recognized value in sharing particular types of information in technology environments in cases where they received information of interest to them. The establishment of these types of information sharing relationships between people and technology has become commonplace in recommender systems at websites such as Amazon. Participant expressed willingness to reveal more about themselves in return for the delivery of timely information in smart and intelligent ways. As such, participants revised their notions of privacy, sharing, awareness, and ambient intelligence.

Participants demonstrated their interest in exploring ways in which to engage in virtual distributed shared listening experiences. Given the opportunity to listen to a radio broadcast, some participants summoned others to share the experience synchronously while using the chat feature to exchange comments, ideas, experiences and suggestions. The experience of sharing and engaging in a shared experience was so important to some individuals that they chose to exit the study if they felt alone or not able to share their social radio tool experience with others. One participant perceived the social radio tool as an opportunity to seek validation for his taste in music among a broader audience. Based on broader audience feedback, the participant could then demonstrate to friends, currently unable to appreciate his musical tastes, that his musical choices could be understood and appreciated by others.

Faculty described use of the tool for research purposes in support of research funding and doctoral student advising. Doctoral students interpreted the tool as a space for sharing research work and related ideas and opportunities.

3.3. Serious Applications

Through playful interaction and consideration of the WeJay tool, a range of serious applications were suggested. With the utilization of user data streams based on the combining of wireless technology and social networks, one participant suggested the potential for the development of unique applications, informed by people's interests and behaviors. For example, one proposed use of the tool pertained to healthcare. Where an individual may experience irregular heart events, the WeJay tool could be adapted to continuously monitor health information. This information could be communicated to one's doctor, making available data on random and rare events contributing to enhanced possibilities for diagnosis and treatment.

Another proposed use of the WeJay tool was designed to support vehicle troubleshooting and maintenance, enabling the monitoring and detection of irregular noise. Data monitoring could be shared in vehicle troubleshooting spaces where others could collaboratively contribute to suggestions and solutions. The capture and reporting of this type of irregular event information occurring with a vechicle could also be shared with one's vehicle maintenance centers to assist in rapid diagnosis and solutions.

The ability to leverage the contents of text generated through playful and other types of interactions was emphasized. The analysis of text content, the conversion of text content to audio, and the mixing of audio with other media types was conceptualized for learning analytic [54], [55] purposes relevant to education and other emerging big data capabilities.

4. Discussion

Reflecting on the two key questions of interest in this paper, a discussion will follow in terms of autonomy, diversity, and opportunities and challenges. The two key questions of interest were:

1. What is the nature of *playful interactions* within ambient-aware wireless grids?

2. What form does *serious gaming* take in ambient-aware wireless grid environments?

This research work is revelatory in terms of the importance of what began as playful interactions with a social radio tool and what emerged in relation to play and games in terms of insights and the power of playful interaction and games to inform, educate, and support learning. As such, the use of playful interactions and serious games in AmI-infused wireless grid spaces would seem to adhere to the notion of serious games as articulated by Michel and Chen [36], games for change that are designed to make a difference [40], and transformative games as advanced by Schell [42], and transformative play as developed by Nicholson [40].

4.1. Autonomy

A common experience for participants during use of the WeJay tool was the importance of the autonomy capability. Being able to create a radio station, host and co-host a station, create content, and broadcast the content to friends, family, and colleagues proved to be a highly motivating, compelling, and engaging activities. As an early stage beta tool the WeJay product presented 'readiness issues' contributing to barriers and limitations to use. In mitigating this issue, participants were encouraged to imagine use and interpretations for use which proved highly effective and confirmed the value of this technique when studying emerging technologies [56].

This research work confirms the importance of being able to create content, engage in experiential learning, explore, collaborate, personalize, and experiment. These activities are considered to be elements critical to generating meaning in 'ludic learning spaces' [57] through "transformative games, play, and learning" as articulated by Nicholson [40].

4.2. Diversity

Faculty and students spanned five decades in age ranges and playful interactions together with serious interpretations for use were in evidence across the age spectrum. Similarly, participants were well represented by gender and a broad range of domains (e.g., engineering, business, management, information sciences, computer science, information technology, communications, law, etc.). Domain diversity speaks to the transdisciplinary nature of the ambient intelligence and the wireless grids domains.

4.3. Ambient Intelligence and Awareness

Through playful interactions; the imagining and conceptualization of serious games; and the engagement in conversations about the tool use experience;

it was possible to have discussions with participants about types of awareness, smartness, and ambient intelligence. When participants engaged in conversations about awareness and came to understanding the meaning of awareness systems and embedded intelligence, examples of affordances were described in relation to the tool under study as well as in realtion to other social media sites. Participants immediately recognized the benefits of various forms of awareness and the potential challenges related to privacy, security, and other unintended consequences.

For the most part, participants called for an enhancement of existing awareness capabilities in wireless grids tools and the addition of other and more extensive awareness features. Indeed, awareness capabilities were found to be critical and key to the development of wireless grid enabled tools going forward, as next generation technologies.

Following the use experience with, or exposure to, the WeJay social radio tool, participants seemed to undergo a shift in thinking as they engaged in conversations about ambient intelligence and smartness. An openness to the possibilities and potentials of smart and intelligent information systems emerged. However, participants were vocal and clear about the importance of people being involved in the design and development of such systems and that such systems incorporate and accommodate human-centered considerations and autonomies.

4.4. Opportunities and Challenges

Many of the opportunities and challenges identified and discussed by Sturm and Sebouten [29] pertaining to ambient gaming and play were confirmed by this research study [2], [3]. In particular, opportunities related to education, learning, natural and improved interaction in real-world contexts, advanced awareness, engaging experiences, co-creation, and participation were in evidence. Regarding challenges, issues of privacy emerged in addition to concerns with security, content copyright, and tool readiness. This study also confirmed the presence of socio-technical issues as well as the importance of the emotion dimension referred to as affective computing [38], [58], [59].

As an early stage tool in beta testing, the product while under study did not support a large sample size in this particular iteration. With a limited number of participants, the full value and impact of playful interactions and serious gaming with a social media tool in the form of a social radio application was somewhat tempered in this study. Participants lamented such limitations and other tool readiness issues. However, it is worth noting that without exception, all participants expressed interest in the next iteration of the product and indicated their desire to use an enhanced version of the tool.

Opportunities and challenges presented by this research study provide a rich agenda for research and practice.

5. Conclusion

In conclusion, research on ambient intelligence (AmI) with wireless grids contributed important insights into the emergent aspects of playful interactions and serious games. Insights pertained to a range of elements for participants, including:

- The motivational aspects of wireless grid tools such as WeJay which allow for and enable user autonomy;
- Meaningful conversations generated beyond the playful interaction environment, extending to broader engagements about the tool with friends, family, colleagues and others;
- Real world experience with content creation and sharing and the opportunity to consider and discuss associated privacy, security, and copyright issues and concerns;
- Emergent approaches to learning where one participant would offer to provide a tutorial on using the tool to one or more other participants;
- Paradoxical understandings of smart environments indicated a recognition of awareness on the one hand and an unspoken expectation or taking for granted on the other hand;
- Willingness and interest in engaging in conversations concerning smart environments, intelligent information systems, and embedded awareness environments;
- Smart and intelligent systems and environments incorporate and accommodate human-centered considerations and autonomies;
- Exploration of ways in which to engage in virtual distributed shared listening experiences;
- The shared experience proved critically important to some individuals to the extent that they chose to exit the research study when they perceived themselves to be alone in the social radio tool environment;

– Varied interests contributed to seemingly unlimited interpretations for use when tools are designed and developed with people in mind, with the particular interests of people in mind, and when people are involved in these processes.

Further, this study confirmed the importance of ecologies concerned with playful interaction design as articulated by researchers such as Wakkary, Hatala, and Newby [60]. Presented as a playful social radio tool in support of the creation of radio stations for the broadcasting of music, participants moved beyond music to create, imagine, and interpret use of the tool for many and varied purposes. The potential for transformative and serious game development for news, information, learning, discovery, research, and myriad other purposes quickly became evident. Many opportunities and challenges were encountered contributing in turn to an abundance of research and practice possibilities.

5.1. Research

The emergent nature of this research study allowed for the revealing of insights into playful interactions and gaming in ambient-infused wireless grid environments. As such, this study calls for further research in this area, based on an enhanced wireless grid enabled WeJay tool supporting a more populous research sample. This study also serves as a bridge study for other wireless grids tools under development, including the possibility of simulation studies advanced by Zyda [38], with wireless grids.

The varied nature of emergent playful interactions and the type of focused and purposeful gaming developed and conceptualized by participants provides future guidance to developers and researchers. Work articulated by Brown [61] on the value of play contributes to increased understanding of play.

Elements critical to playful interactions and serious games would seem to have the potential to benefit from the curiosity, interest and engagement dynamic advanced by Arnone, Small, Chauncey, and McKenna [62] in their new research agenda for technology pervasive learning environments, going forward.

Research opportunities indicated by McKenna [63] in relation to awareness and autonomies in 21st century technology pervasive spaces have relevance for playful interactions and serious gaming dimensions addressed in this paper.

5.2. Industry and Practice

Concerned with social interactions and establishing a balance in the people-information-technology dynamic [64], the WiGiT Lab is developing tools that enable users the autonomy to be creators, producers, collaborators, as well as consumers in a digital information world. Using an early stage beta product, research study participants provided extensive guidance for future iterations of the product. As such, industry has much to gain from the type of impact study used in this research.

Such studies, along with work by Wakkary, Hatala, and Newby [60] concerned with playful interaction design could be used to gain early and rapid insight into the value of playful interactions and serious gaming aspects of emerging technologies that may be of potential interest and benefit to an organization.

Acknowledgement

The development of the Wireless Grid Innovation Testbed (WiGiT) is primarily funded by the support of the National Science Foundation (NSF) Partnership for Innovation (PFI) program grants NSF #0227879 (2002-2006) and continued under NSF # 0917973 (2009-2011).

References

[1] A. Ramnarine-Rieks, L.W. McKnight, and R.V., Small, Collaborative learning through wireless grids, *Hawaii International Conference on System Sciences* (HICSS 44), Hawaii, 2011.

[2] H.P. McKenna, *Ambient Intelligence with Wireless Grid Enabled Applications: A Case Study of the Launch and First Use Experience of WeJay Social Radio in Education*, Doctoral Dissertation, Syracuse University, 2012.

[3] H.P. McKenna, M.P. Arnone, M.L. Kaarst-Brown, and L.W. McKnight, Ambient intelligence with wireless grid enabled applications: a case study of the launch and first use experience of WeJay social radio in education," Summary of doctoral dissertation. *Proceedings of the 7th International Technology, Education and Development* (INTED) 2013 Conference, 4-6 March, Valencia, Spain.

[4] C. Pearce and Artemesia, *Communities of practice: emergent cultures in multiplayer games and virtual worlds*, Boston, MA: MIT Press, 2009.

[5] L.W. McKnight, J. Howison, and S. Bradner, Wireless grids: distributed resource sharing by mobile, nomadic, and fixed devices, guest editors introduction, *IEEE Internet Computing*, 8(2004), 24-31.

[6] L.W. McKnight (Ed.), *Open Specifications for Wireless Grid Technical Requirements*. Prepared by Syracuse University, Virginia Tech, Rochester Institute of Technology & Tufts University (Version 0.1 approved: WiGiT Group). Sy-

racuse, NY: School of Information Studies, Syracuse University, 2012.
[7] P.Travis, Wi-fi wall jack to enable wireless grid. *Information Week*, 2004. Retrieved July 11, 2012.
[8] L.W. McKnight, Email correspondence, 18 November 2011.
[9] B. De Ruyter and E. Aarts, Experience research: a methodology for developing human-centered interfaces. In: H. Nakashima & J. C. Augusto (Eds.), *Handbook of Ambient Intelligence and Smart Environments*, pp. 1039-1067, New York, NY: Springer, 2009.
[10] N Sebe, Human-centered computing. In H. Nakashima, H. Aghagan, & J. C. Augusto (Eds.), Handbook of Ambient Intelligence and Smart Environments. New York, NY: Springer, pp. 349-37, 2010.
[11] J. Canny, *Human-centered computing* (Technical Report). Berkeley, CA: University of California, Berkeley, 2001.
[12] J Treglia, L.W. McKnight, A. Kuehn, A. Ramnarine-Rieks, M. Venkatesh, and T. Bose, Interoperability by 'edgeware': Wireless grids for emergency response. *Hawaii International Conference on System Sciences* (HICSS 44), Hawaii, 2011.
[13] S. Manvi and M.N. Birje, A review on wireless grid computing. *International Journal of Computer and Electrical Engineering, 2*(3), 469-474, 2010..
[14] J. Marsden, Determining the role of geospatial technologies for stigmergic coordination in situation management: Implications of the wireless grid, *CogSIMA 2011: Cognitive Methods in Situation Management, IEEE International Multi-Disciplinary Conference on Cognitive Methods in Situation Awareness and Decision Support,* Miami, FL, pp. 131-135, 2011.
[15] T. Brooks, J. Robinson, & L.W. McKnight, Conceptualizing a secure wireless cloud. *International Journal of Cloud Computing and Services Science (IJ-CLOSER)*, 1(3), 89-114, 2012.
[16] S. Brown and C. Vaughan, Play: how it shapes the brain, opens the imagination, and invigorates the soul. New York, NY: Penguin Group, 2009.
[17] E. O. Wilson. Sociobiology: the new systhesis. Cambridge, MA: Belknap Press, Harvard University Press, 1975
[18] H. Spencer, The principles of psychology. London: Longman, Brown, Green, and Longmans. 1855.
[19] H. Spencer, Education: intellectual, moral and physical. New York: D. Appleton and Company, 1861.
[20] K. Groos, The play of man. Translated by E. L. Baldwin. New York: Appleton, (1891) 1901.
[21] M. Bekoff, The need for 'wild' play: let children be the animals they need to be, *International Journal of Play*, 1(2):217-224, 2012.
[22] M. Spinka, R.C. Newberry, and M. Bekoff, Mammalian play: training for the unexpected, Quarterly Review of Biology, 76(2):141-168, 2001.
[23] M. Bekoff and J.A. Byers. A critical reanalysis of the ontogeny of mammalian social and locomotor play, an ethological hornet's nest. In Behavioral Development, the Bielefeld Interdisciplinary Project (K. Immelmann, G.W. Barlow, L. Petrinovich, and M. Main, Eds.), pp. 296-337. New York: Cambridge University Press, 1981.
[24] J.A. Byers and C.B. Walker, Refining the motor training hypothesis for the evolution of play. Am. Nat., 146, 25-40, 1995.
[25] M.C. Diamond, Response of the brain to enrichment. Annals of the Brazilian Academy of Sciences, 73(2), 2001.
[26] L. Sortino and L. Wiltse, Playful inquiry. Website. Retrieved 13 April 2013, from http://www.playfulinquiry.com/
[27] M. Sheets-Johnstone, The primacy of movement. Advances in Consciousness Research Series, 14(6). John Benjamins Pub., 1999.
[28] B. Sutton-Smith, Ambiguity of play. Cambridge, MA: Harvard University Press, 1997.
[29] J. Sturm and B. Sebouten, Ambient gaming and play: opportunities and challenges, *International Joint Conference on Ambient Intelligence* (AmI'11), Workshop on Ambient Gaming (AmGam'11), Netherlands, 16-18 November, 2011.
[30] J. Huizinga, Homo ludens: a study of the play element in culture. Boston, MA: Beacon Press, 1955.
[31] R. Caillois, Man, play and games. Simon & Schuster, 1961.
[32] M. Bekoff and J. Pierce, Wild justice: the moral lives of animals. University of Chicago Press, 2010.
[33] R. Hollander, Computing ethics: ethics viewpoints Efficacies – seeking answers to ethical concerns. *Communications of the ACM*, 56(3):33-34.
[34] M. Montola, J. Stenros, and A. Waern, Pervasive games: theory and design. Burlington, MA: Morgan Kaufmann, 2009.
[35] D. Djaouti, J. Alvarez, J-P. Jessel, and O. Rampnoux, Origins of serious games. In M. Ma, A. Oikonomon, and L.C. Jian (Eds.), Serious games and edutainment applications, pp. 25-43. London: Springer, 2011.
[36] D.R. Michael and S.L. Chen, Serious games: games that educate, train, and inform. Mason, OH: Course Technology, Cengage Learning, 2006.
[37] European Union, What a serious game is? Definitions and theoretical framework for serious games. Ludus. Retrieved 11 April 2013 from http://www.serious-gaming.info/@api/deki/files/57/=Chapter_1.pdf
[38] M. Zyda, From visual simulation to virtual reality to games. Computer, 38(9), pp. 25-32, September 2005.
[39] S. Nicholson, A user-centered theoretical framework for meaningful gamification. Paper presented at Games+ Learning+Society 8.0, Madison, WI, June 2012.
[40] S. Nicholson, Strategies for meaningful gamification: concepts behind transformative play and participatory museums. Presented at Meaningful Play 2012. Lansing, MI. Retrieved 11 April from http://scottnicholson.com/pubs/meaningfulstrategies.pdf
[41] S. Deterding, R. Khaled, and D. Dixon, Gamification: toward a definition. CHI 2011, May 7-11, Vancouver, BC, Canada, ACM, 2011.
[42] J. Schell, What games are good at. Presentation at the 9th Annual Games for Change Festival. New York, NY, June 2012.
[43] SGA, Major study of the impact/future of serious games, Serious Play Conference, Aug. 19-22, 2013. Santa Monica, CA: Serious Games Association.
[44] A. Sears, J. Lazar, A. Ozok, and G. Meiselwitz, Defining an agenda for human-centered computing. *Bulletin of the American Society for Information Science and Technology*, **34**(2008) 35-37.
[45] NSF, *Human-centered computing*, Arlington, VA: The National Science Foundation, 2013. Retrieved 7 January 2013 http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503302&org=ISS.
[46] T. Bekker, J. Sturm, and B. Eggen, Designing playful interactions for social interaction. *Personal and Ubiquitous Computing*, 14(5), 385-396, 2010.
[47] E.H.L. Aarts and S. Marzano (Eds.), *The new everyday: views on ambient intelligence*, Rotterdam, 010 Publishers, 2003.

[48] G. McKenzie, Gamification and location-based services. *Workshop on Cognitive Engineering for Mobile GIS 2011 in Conjunction with the Conference on Spatial Information Theory (COSIT) 2011,* Belfast, Maine.

[49] H. Cramer, Z. Ahmet, M. Rost and L.E. Holmquist, (2011). Gamification and location-sharing: some emerging social conflicts. *CHI2011,* Vancouver, BC, 2011.

[50] R.K. Yin, Case study research: design and methods (Fourth Edition). Thousand Oaks, CA: Sage, 2009.

[51] M. Denscombe, The good research guide for small-scale social research projects (Fourth Edition). Maidenhead, Berkshire, UK: Open University Press, 2010.

[52] A. Jackelen, Emergence theory – What is its promise? Emergence everywhere! Reflections on Philip Clayton's mind and emergence. *Zygon*, 2006, 41(3), pp. 623-632.

[53] S. Johnson, *Emergence: the connected lives of ants, brains, cities, and software*. New York, NY: Simon & Schuster, 2001.

[54] L. Johnson, S. Adams Becker, M. Cummins, V. Estrada, A. Freeman, and H. Ludgate, NMC Horizon Project Report: 2013 Higher Education Edition. Austin, TX: The New Media Consortium, 2013.

[55] R. Bass, "Disrupting ourselves: The problem of learning in higher education." Educause, March/April 2013.

[56] U. Felt, S. Schumann, C. Schwartz, and M. Strassnig, Technology of imagination: a card-based public engagement method for debating emerging technologies. Vienna, Austria: Department of Social Studies of Science, University of Vienna, 2012.

[57] A. Kolb and D. Kolb, Learning to play, playing to learn: a case study of a ludic learning space. Journal of Organizational Change Management, 23(1), pp. 26-50, 2010.

[58] K.R. Scherer, What are emotions? And how can they be measured? *Social Science Information, 44*(4), 695-729, 2005.

[59] I. Lopatovska and I. Arapakis, Theories, methods and current research on emotions in library and information science, information retrieval and human-computer interaction. *Information Processing and Management, 47*(4), 575-592, 2011.

[60] R. Wakkary, M . Hatala, and K. Newby, ec(h)o: ecologies for designing playful interactions, In J. Frascara (ed.), Designing effective communications: creating contexts for clarity and meaning. New York, NY: Allworth Press, 2006.

[61] S. Brown, Stuart Brown: play is more than fun [video], TED.com, 2008.

[62] M.P. Arnone, R.V Small, S.A. Chauncey, and H.P. McKenna, Curiosity, interest and engagement in technology-pervasive learning environments: a new research agenda, *ETR&D*, **59**(2010), 181–198.

[63] H.P. McKenna. Ambient intelligence and information interactions: theorizing 21st century autonomies and awareness for technology and people in balance. Article currently under review.

[64] H.P. McKenna and S.A. Chauncey, Social interactions with wireless grids: conceptualizing 21st century ambient information society, *Proceedings of the International Conference on Information Society (i-Society 2013), 24-26 June, Toronto, Canada, 2013*. In press.