EXPLORING CYBERLEARNING IN WIRELESS GRIDS

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Abstract

This paper introduces wireless grids and discusses its potential impact on cyberlearning by presenting specifications and features under consideration as well as a roadmap which guides our current work. Mechanisms for cyberlearning environments need to be devised to support peer-to-peer communication, in addition to human-computer communication, where human users and software agents coexist and interact. Wireless technologies are resulting in escalating transformations of the educational world. The question is; how are wireless technologies affecting the learning environment and pedagogy? We propose the exploration of wireless grids technologies to find answers. Much of the literature describes wireless technologies as a tool; they do not control learning, nor do students program them. This is where wireless grids technologies are poised to include this missing dimension. That is improving the process of interaction, negotiation and collaboration so that students have an active and constructive role in the learning process. Wireless grids are an emerging technology that enables ad hoc sharing of resources on edge devices (such as mobile Internet devices, laptops and mobile phones). The technology was initially conceived, architected, demonstrated and evaluated under a prior exploratory National Science Foundation (NSF), Partnership for Innovation (PFI) grant (#0227879). In this paper we describe the current project that is being undertaken under the NSF PFI grant (# 0917973). It is an interdisciplinary Electrical Engineering and Information Management senior capstone course that will be taught jointly among Syracuse University, Virginia Tech and Tufts University. Students from each of the campuses will be able to remotely deploy experiments on the network at the other campus and be actively involved in designing their own personal wireless grid or "gridlet". Our study is guided by research that focuses on the sociological implications of pervasive communication tools on many aspects of cyberlearning. We hypothesize that cyberlearning through wireless grids has the potential for supporting constructive and collaborative learning by helping students find and organize information in context, construct their understandings, communicate those understandings to others and build and design applications together to meet their specific needs. .

Keywords: Cyberlearning, Collaborative learning, Computer Supported Collaborative Learning (CSCL), Wireless Grids, Online learning, Virtual Learning Environment, Distributed Collaboration, Socio-technical Systems.

1 INTRODUCTION

As we advance into the information age, critical thinking becomes even a more important element in the learning process. Didactic learning in which students are subjected to repeated lectures no longer depicts the role of faculty. The phenomenon of learning is being transformed into an empowerment process whereby curiosity, imagination, and shrewdness replace structure. The NSF Task Force on Cyberlearning report titled "Fostering Learning in the Networked World: The Cyberlearning Opportunity and Challenge" discusses cyberlearning as having the potential to transform education throughout an individual's lifetime by enabling customized interaction with diverse learning materials on any topic. The overall idea is that learning does not stop with K–12 or higher education; cyberlearning supports continuous education at any age. One of the report's question is how can the best of cyberlearning advances in the universities and industry be leveraged upon? [1].We have seen that the widespread use of technology has allowed higher education institutions to design programs where cyberspace holds the possibility of attracting a larger and more diversified student population. Learners in cyberspace are active and creative and cyberlearning allow student and instructors to collaborate and participate in learning activities anytime and anywhere. There are many different terms that describe learning through the use of technology, so when we speak of cyberlearning we are referring to the interactions among students, the interactions between instructors and students and learning that results through these interactions by collaborative activities. Theorists and proponents of cyberlearning claim this approach form new communities [2], [3]. Cyberlearners build communities by adopting openness, flexibility and humor, honesty and a willingness to take responsibility for community formation and work collaboratively [3]. A major problem in the research and development of learning systems is how to provide organized effective support for communication, interaction, and collaboration in networked cyberlearning environments [4]. Mechanisms for cyberlearning communities need to be devised to support peer-to-peer communication, in addition to human-computer communication, where human users and software agents coexist and interact.

We see the application of wireless grid technologies as fostering the development of these communities. While a typical distributed learning environment provides an environment where resources can be shared allowing dispersed students to participate in learning; collaborative learning and community building aspect puts more emphasis on providing a shared workplace for students to interact and learn through cooperation.

2 BACKGROUND

Cyberlearning can be described as learning that is mediated by networked computing and communications technologies. The choice of the term is deliberately parallel to “cyberinfrastructure,” a term coined at NSF and is now widely used [1]. Grids has the potential to resolve the shortcomings in existing cyberlearning, such as scalability, interoperability and availability. It also provides new possibilities for further development and understanding of cyberLearning, and constructive, cooperative and collaborative learning.

2.1 Why the Interest in Cyberlearning?

Cyberlearning embraces new paradigms of learning and uses methodologies through distant online communication, networks and software designed for learning. The interest is mainly driven by serious growing concern that the United States is not preparing a sufficient number of students, teachers, and practitioners in the areas of science, technology, engineering, and mathematics (STEM). Over the years a large majority of secondary school students fail to reach proficiency in math and science, and many are taught by teachers lacking adequate subject matter knowledge. When compared to other nations, the math and science achievement of U.S. students and the rate of STEM degree attainment are dismal [5]. It is also partially fuelled by the rapid development of sophisticated technologies and its availability at lower costs as well a variety of social and economic pressures, such as pressures to expand access to higher education, to lower the costs of higher education, to provide opportunities for lifelong learning. More importantly critics argue that popular applications of instructional technologies tend to emphasize technology over course content and are best used when the type of learning required is simply memorization rather than synthesis and analysis. More importantly, there are concerns that cyberlearning may eliminate crucial personal interactions not only between instructors and students but also between students as well, leading to a depersonalization of the learning process. Proponents argue that cyberleaming provides students with far greater access to information and other educational resources. They see it as a cost-effective way to provide more individualized instruction and more accommodation for different learning styles. Additionally they claim that using technology for teaching and learning can promote greater involvement in learning and more individual responsibility for learning, that it supports a constructivist theory of education in which students actively construct an internal representation of knowledge by interacting with the materials to be learned, usually in a collaborative setting [6]. Knowing how people learn is a critical component of cyberlearning and requires new forms of expertise, new collaboration skills, new types of partnerships. The key players are the (1) students who need to embrace alternative ways to interact with instructors and classmates (2) instructors who have to modify their teaching styles and curriculum to fit the new environment (3) support services that ensure that the technology is always available and (4) administrators who need to work closely with the institution's resources to ensure success.

2.1 Wireless Grids as a Solution

Current learning platforms do not support all requirements of collaborative lifelong learning; therefore it is valuable and necessary to find appropriate solution for how to build such platforms in grid environments. In cyberlearning, there have many isolated platforms, in which learning objects/functions are platform-dependent and cannot be used outside the system, and the collaboration between actors of different systems becomes complicated. Therefore, cyberlearning as it stands encounters many challenges, which increasingly addresses learning resources/services sharing, reuse and interoperability [6]. Further, cyberlearning requires a common, open platform to support communities of developers and learners in ways that enable both to take advantage of advances in the learning process. The platform architecture must be designed so that it can evolve, especially over the coming decade as computing shifts come into their own [1]. This is where wireless grids technologies come to the rescue.

Grid computing is usually referred to as a type of network computing in which the unused processing power of numerous computers is combined, the goal being to solve information intensive problems that are too large for individual computers to handle. Much of grid software technology addresses the issues of resource scheduling, quality of service, fault tolerance, decentralized control, security etc. A very well-known example of grid computing is the analysis of radio telescope data to search for extraterrestrial intelligence (SETI) [8]. In contrast to the sharing of processing power in these large, predefined projects, the sharing that takes place in wireless grids is not only directed at sharing processing power, but at combining a wide range of other resources such as screens, wireless signal, microphones on edge devices such as cell phones, PDA's, or laptops. It is more locally and ad hoc oriented so that users can come and go in the local and ad hoc wireless network [9]. Therefore, wireless grids are defined as the ad-hoc dynamic sharing of physical and virtual resources among heterogeneous devices [9]. In other words you can hook up any laptop in a room to a projector without having to connect through cables, distributed audio recordings using the microphones of wireless devices such as mobile phones and laptops to create stereo or surround sound recording and location aware PDA's to create smart buildings that help individuals navigate through the building and communicate with others [9]. This ad hoc distributed resource sharing allows these devices to offer new resources and locations for grid computing [10]. The wireless grid software basically has two functions. First, it is capable of discovering resources within the wireless network and, secondly, it facilitates the sharing of resources. In contrast to, for example, Bluetooth, wireless grids does not create the wireless infrastructure, but uses the resources that are already available, whether they are Bluetooth, WLAN or 4G+. It uses this available infrastructure to provide applications such as screen sharing on top of these infrastructures. To summarize, the most important characteristic of wireless grids in this research is that it allows for the sharing of resources on edge devices. The idea is sharing can take place in a public and private context, between partners that are known to each other or that may be strangers.

3 ONGOING WIRELESS GRIDS RESEARCH

Our present exploration builds on previous research and development that was done over the years. In this section we briefly discuss our findings. General research in wireless grids has sparked the development of new types of applications to utilize the new services offered by the concept. One of the main advantages of wireless grids is that they can reach both geographic locations and social settings that computers have not traditionally penetrated. Thus, new services, that were nonexistent before, will be offered through wireless grids. However, the implementation is not without its obstacles. From the technical perspective a typical individual wireless device does not have enough resources to support sophisticated collaborative applications. For example, it has limited computational, communications, and battery power capabilities. It is also found in highly mobile ad-hoc contexts that are characterized by rapid, unpredictable changes in device availability and connectivity. The scope of wireless grids, in some ways, resemble networks already found in connection with agricultural, education, military, transportation, air-quality, environmental, health, emergency and security systems [11].

3.1 Taking the Concept out of Lab

Our previous NSF PFI funded project (Virtual Markets and Wireless Communication and Computational Grids – NSF #0227879) led to the identification of the market mechanisms and usability features that can drive the adoption of these innovative solutions. The project identified the need for small grids, middleware and 'edgeware'. Market mechanisms for developed and developing countries were considered and usability features in the commercial, education, emergency, and medical sectors that can drive the adoption of new grid solutions were also identified. Related work included works on user and socio-technical perspectives and challenges [12], [13]; coordination of user and device behaviours [14]; future internet applications and bridging communicative channels [11], [9], [14]. Under this grant the team established the Wireless Grids Lab and a proof of concept developed as a modest initial application call DARC* (pronounced "dark star"). This exploratory software development led to the first public controlled experiment at the Museum of Science, Boston where a two week 'Wireless Grids Summer Institute' (WGSI) was held in July 2005. The experiment was done with 24 high school students from Malden, Medford, and Everett; three urban-rim school districts in Massachusetts. Two key research questions were (1) how do the students use Wireless Grids during the two week period of the summer course? (2) knowing the capabilities of the technology, what other applications besides screen- and audio-sharing do students think are viable for Wireless Grids? The program was built around STEM disciplines where students were engaged in science-based activities. Pre and post surveys were used to determine intrinsic motivation and self-regulation and assess participants' interest and enjoyment, perceived competence, effort, value and usefulness, pressure and tension, and perceived choice while performing a given activity. Analysis showed that motivation was held constant during the WGSI period. Curiosity and content learning of information technologies significantly increased. However, overall analysis led us to conclude that there was no significant learning or behavioral changes over the two week period. In retrospect, it was perhaps naïve to think that a two-week experimental exposure to wireless grids would be sufficient time to observe a change in attitudes or measureable learning; but at that point in time that was all that could have been managed with the technology at its level of development.

Focus groups were done with 20 faculty and staff members and graduate students to measure the value of wireless grids outside the laboratory from a user perspective and its potential diffusion model [12]. The results illustrated that although people see the relative advantage of wireless grids, they feel reluctant to share the resources on their edge devices with people they hardly know or in a social context with which they are not familiar. Issues relating to security and privacy created a lack of trust were a potential issue.

Over time the application was developed and eventually trademarked as Innovaticus. Trials of the updates were offered at the dorms to 284 students at Syracuse University (SU). The objective was to determine if people were willing to share resources, i.e. the condition that has to be fulfilled for the adoption of wireless grids [10]. The research approach was based on three research methods factorial survey, policy capturing or vignette studies, and conjoint measurement. The dorm trials showed that people were only willing to share in a trusted context, but trust could have been influenced. These studies show that concept of trust was a key factor and a very complicated issue that would need to be addressed more closely in future studies.

4 DEVELOPING PARTNERSHIPS

Inspired by these findings from exploratory research, we organized a global wireless grid partnership to facilitate industrial, academic, and government research and collaboration in this emerging field of study. Fig. 1, highlights the wide range of applications and services foreseeable and expected to emerge from the development of a key enabling technology – a standard 'sharing protocol' for wireless grids [15]. The figure also illustrates that from very early it was clear that a wide range of novel applications could potentially emerge for use across physical and virtual spaces.

4.1 Wireless Grids Innovation Testbed (WiGiT)

SU and Virginia Tech (VT) created the first national Wireless Grid Innovation Testbed (WiGiT) [16]. The project is currently supported by the NSF/PFI grants, NSF # 0917973 and also involves leading partners from Massachusetts Institute of Technology (MIT), Tufts University and Instituto Superior Tecnico – Lisbon. At SU, WiGiT will test 'edgeware' or software that resides beyond the cloud, across edge network devices, both wired and wireless. At Virginia Tech, WiGiT will also evaluate how such applications might perform on a recently established wireless cognitive radio network testbed (VT-CORNET).The primary goal WiGiT is to bring together unique technical assets from SU and VT for further evaluation and to establish a baseline set of open or public interfaces, specifications, or standards, for wireless grids. Technical issues that are ripe for further research and analysis as part of this process will be supported by WiGiT, including design and manufacturing, application performance and optimization, characterization of networks for wireless grid applications, protocol development, policy and usability. Evaluation of service engineering simulations, user behavior trials, application tests, security models, and trust frameworks for wireless grids will be among the issues explored through the testbed, by faculty, students, and organizations. The uniqueness of this project lies in its combination of new technologies for 'edgeware' for grid or cloud computing applications across edge devices, with wireless networking. The potential influence of this combination on current wireless connectivity standards will be explored. The project will also investigate the wireless grids' utility to digital communities (including open source technical development communities) in being able to work and collaborate in a distributed, mobile fashion.

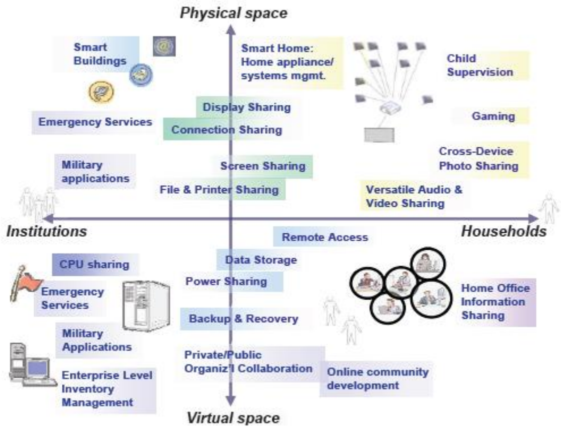

Figure 1. Technology roadmap for wireless grids
(Courtesy of Wireless Grids Corporation)

Ultimately, WiGiT expects to be at the center of an emerging industry serving new markets through its distributed incubation of wireless grid applications, training and workshops. By incubating technology and teaching, both knowledge spillover and transfer between testbed partners and their real/virtual communities will flow, creating an "entrepreneurial ecosystem" that encourages exploitation of opportunities to transform user practices and system designs into novel tools and products. Presently WiGiT involves partnerships nationally and globally and permits easy access to its main findings and activities, thereby benefiting individuals, researchers as well as companies including media worldwide, in both developed and developing countries, spurring further innovation and economic growth on top of these NSF-derived technologies.

5 OPEN SPECIFICATIONS PROCESS

We have been working on the development of a testbed aimed at serving as an academic and industry research playground for the structuring and articulation of open standards and application [13] programming interfaces for wireless grids. Inspired by Free/Libre Open Source Software (FLOSS) development processes, WiGiT team members contribute to the Virtual Organization (VO) which will issue initial recommendations by participating in meetings and providing feedback and by contributing beta or alpha software implementations for experimentation by WiGiT partners. Through rough consensus of WiGiT meeting/web conference participants, standards will be established and shared. WiGiT anticipates defining through iterative and flexible processes modular components which can be mixed and matched as partners wish (see Fig. 2). This illustrates a unique architecture, in which 'edgeware' – which we claim is an entirely new class of software - operating across distributed edge devices, effectively wraps around devices, software, services and content in both cloud and grid environments and enables the creation of an array of 'gridlet' applications for specific purposes, among consenting communities of people, devices, and resources. WiGiT's open specifications may or may not be employed by devices and services relying on the open specifications for VT cognitive radios defined by CORNET. It is envisioned that with this 'mix and match' approach, faculty, students and firms will be empowered to create their own gridlets for optimal use across heterogenous IEEE 802.15.5 (low power wireless mesh), WiFi (IEEE 802.11), 3G and 4G protocols and on to Next generation Networks (NGN). The idea is that community members will determine how the WiGiT process will change, and which partner organizations may join in to contribute broadening participation in WiGiT activities.

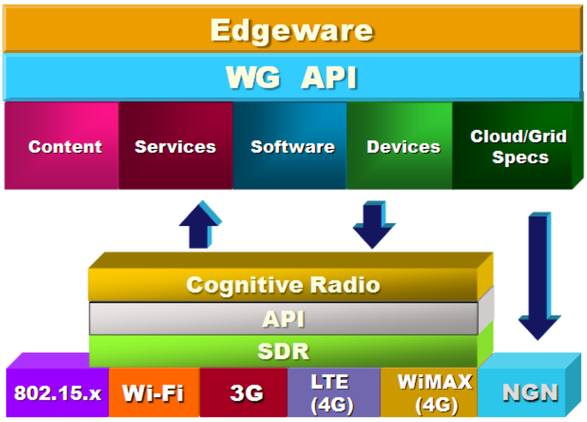

Figure 2. Components of WiGiT
(Courtesy of WiGiT)

Since WiGiT expects partners to share and contribute resources – including experimental results – every partner is also potentially an experimental subject. Management and digital curation of a growing experimental data sets is an issue that must be addressed as WiGiT evolves, but for which guidelines are still nascent and undergoing development.

6 PROPOSED COURSE FEATURES

Within our current NSF PFI [16] funding our project we are developing an interdisciplinary Electrical Engineering and Information Management senior capstone project will be developed using wireless grids for spring semester 2011 and will be taught jointly among SU, VT and Tufts University. We will teach a group of students how to use the wireless grid (at SU) and a cognitive radio network testbed (at VT) to run a variety of applications for the wireless grid. Students from each of the campuses will be able to remotely deploy experiments on the network at the other campus. Each project group will consist of students from all of the three campuses. Participation from Portugal's Instituto Superior Tecnico, and a Portuguese next generation network testbed operated by UMIC may be integrated by the following year. They will implement a web based user interface capable of acquiring data from wireless sensor networks. Wireless sensor network data will be acquired through an Ethernet based base station and Java code will be used to parse collected information and display them. To do this project, students will learn TinyOS, Java, sensor network and wireless grid topology. Once familiar with the sensor network topology, they will design a program that will be capable of reconfiguring a wireless sensor network. This is done through writing new code instructions to the wireless sensors, i.e. reprogramming wireless sensors. Therefore they will write a program that can inject commands into a sensor network via the WGiT and we will run the localization application on the sensor network.

To allow students to share devices some preliminary solutions before the course will be explored and solutions will be articulated. At SU students in a variety of courses and through work at the associated labs will be provided with hands-on experience in the use of the wireless grid beta applications as they become available. The expectation is that in time, students will be able to easily develop their own wireless grid applications, building upon the platform provided. All instructors that are involved will receive professional development training in the technologies and in distance learning pedagogy. Students will learn how to develop "gridlets" that can be incorporated into the course design. The course modules will be revised, to incorporate virtual buddy/e-mentoring components will be developed and integrated and tested across wireless grids-enabled online classes. A pilot test of the revised course containing components will be implemented and evaluated in an online class (this is presently being conducted). Through the testbed, students at participating institutions will interact directly with each other, as they design and use a variety of wireless grid applications as they are introduced, whether as proof of concept or prototype.

6.1 Theoretical Framework

Our study is guided by previous empirical research that focuses on the sociological implications of pervasive communication tools on many aspects of life, including work and education. We are aware that simply providing new technologies in a learning environment does not guarantee a learning community. As noted by Salmon the emergence of new technologies has, so far, done little to expand the conception of teaching as being ‘‘an individual and traditional craft” [17]. An online learning community is structured around four elements – communication, collaboration, interaction and participation [18]. For learning to flourish, trust is a basic prerequisite. This is important to the socialization process and creates common understanding and development of trust within the group [19]. Collaborative interaction and participation is central to the socio-constructivist perspective on learning; a perspective that undergirds much of CSCL research [20] which will guide our exploration.

Social cognitive theory has been extended and applied to a number of related disciplines, such as: organizational research and educational issues. More specifically, according to Lave & Wenger social practice is the means to understanding the complexity of human thought that is situated in real-life settings [21]. Presently we are involved in piloting a variation of the proposed course described above. We are working with two teams of students and drawing upon the theory of learning as a social practice [20], particularly on legitimate peripheral participation (LPP) which is the conceptual bridge between a person and the community of practice (CoP). The idea is that as people participate in CoP they become more knowledgeable in the practice. They move from a position of newcomers to becoming old-timers with greater mastery of the practice and with all the conflicts, contradictions, changes and stability that it entails. Social practice and not learning is the starting point [21]. Learning is increasing participation in CoPs and concerns the whole person acting in the world. Therefore learning is not a condition for membership, but is itself an evolving form of membership. Since this is a capstone course for undergraduates who will soon be out in the working world, it can provide a means of explaining the developing identity of students.

7 Methods and Analysis Tools

The principle research question guiding our explorations is to what degree can wireless grid technologies can be used to successfully create a distributed, synchronous and asynchronous, collaborative learning environment. Both projects will be the development and testing of a wireless grids-based collaborative learning model in which student knowledge creation and acquisition is facilitated by the use of a variety of seamlessly integrated technologies for learning [22]. The application of this model during the iterative design process will provide data that will increase our understanding of whether and how (1) engagement in the design of and control over their own learning positively affects student learning and motivation outcomes; (2) social and technical factors affect the quality and quantity of interactions of virtual collaborative learning teams; (3) the use of specific technologies individually and collaboratively influence student learning and motivation; and (4) collaboration between instructors to provide learning support affects students’ learning and motivation.

In addition to documenting how well the course components function individually and in combination throughout the iterative design process, data will be collected using a variety of data gathering methods including online surveys, individual interviews and focus groups, reflection documents, distance learning and social networking data logs, and assignments to determine if specific project outcomes have been achieved. Tools such as SelectSurvey (an online survey data collection/analysis system); the Provalis Research Suite (QDA Miner, Wordstat, Simstat) for mixed methods analysis, social network analysis and visualization; SPSS (statistical analysis program); and AtlasTI (qualitative data analysis program) will be used by the project team to collect/analyze data.

8 CONCLUSIONS AND IMPLICATIONS

In this paper we have presented the possibilities of wireless grids technologies in implementing an innovative platform for cyberlearning. We have placed particular emphasis on showing the advantages that can be obtained in deploying this environment. Much work must be done both in the identification and in the implementation of the functionalities that the new platform must have but, as we hypothesize it can potentially facilitate the emergence of a new learning models, user centred and not content centred, built upon grid technologies.

We believe that our findings will directly impact the intellectual capabilities of our higher education institutions by initiating a sustained dialog into the increasingly critical requirements advancing technologies in cyberlearning. The ultimate vision of the wireless grid is that of an adaptive network with secure, inexpensive, and coordinated real-time access to dynamic, heterogeneous resources, across geographic, political and cultural boundaries without forsaking stability, transparency, scalability, control and flexibility. The testbed will support training and courses related to innovation, wireless grids technologies and educational/social impacts opportunities. Students within a variety of courses and through work at the associated labs will be given the opportunity of hands-on experience in the use of the wireless grid beta applications as they become available. Students will have the opportunity to develop their own personal wireless grid applications, building upon the platform provided. We believe that our efforts will serve as a catalyst to build a broad-based community of researchers and students epitomizing the concept of cyberlearning.

9 FUTURE CYBERLEARNING EXPLORATIONS

Another proposed three year project (awaiting funding) will introduce K-12 students to wireless grids technology to dynamically mesh devices, content, and users, permitting the formation of a network or grid of devices without a dedicated server needed to manage the network [23]. The project team includes Syracuse University, State University of New York College of Environmental Science and Forestry, Syracuse City School District, Clear Channel Radio, and Wireless Grids Corporation. We will use a wireless grids platform to develop an accessible, multimedia, distance learning course for upper level students in five urban high schools. Wireless grids will seamlessly integrate all required applications (e.g., distance learning, social media, gaming) and deliver a highly interactive, problem-based course, “The Global Environment and Human Culture,” accessible through laptops and mobile technologies. Students will use social media to communicate within and across schools, and learn about and use wireless grids to work collaboratively in teams with students in other schools, sharing information and resources, creatively seeking solutions and business opportunities in environmental problems posed in the course. The research goal is to produce transformative and collaborative knowledge creation.

The proposed project’s research will focus on the outcomes of the cyberlearning experience that address subject matter and digital literacy knowledge/skills, inquiry and motivation, virtual collaboration, and technology versatility. In addition to documenting how well the course components function individually and in combination throughout the iterative design process, data will be collected using a variety of data gathering methods. Data analysis will focus on identifying interactions within social networking systems; such as how students develop trust in each other and their instructors, e-mentors and buddies; and how leadership and collaboration occur within learning teams. Other factors for analysis will be the incorporation of technology scaffolding and universal accessibility principles in the course design. [23]. This research addresses the current lack of knowledge about effective utilization of cyberlearning technology by teachers and administrators. Therefore it will allow for better assessment of wireless grids protocols and applications will inform design, manufacturing and commercialization of these next generation information and resource sharing innovations.

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