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Experience With A Multidisciplinary Project For Social Services

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Experience With A Multidisciplinary Engineering Project For Social Services

Orienting projects toward social services introduces and motivates students to real-world problem solving in an engineering curriculum. While service learning has gained traction in recent years, only a few papers in the literature have addressed the development of assistive technologies as a focus for engineering project applications. Over the past eight years, the Collaboratory for Strategic Partnerships and Applied Research at Messiah College has fostered several interdisciplinary undergraduate student and faculty projects, such as the assistive communication technology Wireless-Enabled Remote Co-presence (WERCware) described here. WERCware is designed for those who depend on job- or life-coaching, to ameliorate cognitive and behavioral challenges that affect performance at home or in the workplace. It facilitates remote communication between coach and consumer, for training and/or other support as needed, to increase independence of the consumer. WERCware development, as a collaborative effort between Messiah College and a small company, has gone through several fits and starts including sporadic seed grant funding, angel investor interest, multiple field trials, consultant contributions, and attempted commercialization. These phases have exposed students to technical challenges of electrical and computer engineering outside the formal classroom, but also have required an interdisciplinary mindset to understand the social need and recognize realistic hurdles inherent to getting a product from development to market. Previous papers have addressed the competitive student team member selection process and assessment of the credit-bearing project work in our engineering project curriculum at Messiah College. This paper focuses on WERCware as an extended duration example of multidisciplinary undergraduate project work, highlighting lessons learned by both students and faculty from the experience.

I. Introduction: Contribution of Work & Case Study History leading to Lessons Learned

As an opportunity for rich multidisciplinary engineering applications, social service applications are often overlooked. While benefits of service learning have been widely addressed in literature on engineering education, only a few recent papers have proposed assistive technology as a focus for undergraduate engineering projects.[1-4] None address the need for a system that delivers social services remotely, as suggested here. This paper draws lessons from ongoing multidisciplinary project work by undergraduate engineering students and faculty developing a unique assistive communications technology system to allow remote support. The multidisciplinary nature of project work is exemplified by: students and faculty working as a team across major disciplines or engineering concentrations, engineering students and faculty developing technical solutions to help address a unique social (non-technical) human need, and project team members without prior business background becoming aware of requirements for bringing a product to market. This section focuses on ways social service application and business requirements directed the engineering project work. Later sections of the paper address methods and results of assessment.

Overview of the Social Need, WERCware System and Market Opportunity

Improved outcomes mandated for students with disabilities receiving special education have required schools to spend increasing amounts of time and money preparing students for work after high school. Sadly, while most students with disabilities graduate from high school, the majority never find employment, especially if reliant on the physical presence of a job coach. Of these students and adults, many are capable of independent competitive employment with the right kinds of support. The missing link inhibiting meaningful employment or more independent living is likely to be the need for an assistive, cost effective, disability specific, job coaching system to help them get started, and keep them going. Since 2008, in partnership with a company known as SymBionyx, a communication technology system called Wireless-Enabled Remote Co-presence (WERCware) has been under development to meet this need, while concurrently serving as a rich multidisciplinary educational experience for faculty and students.

In the WERCware concept, a service provider at one location is enabled to be invisibly present with, and sharing the experiences of a consumer with a disability at another location. The consumer receives a service such as job coaching or in-home attendant care while at a location arbitrarily distant from the provider's site. Both the consumer and the provider maintain wireless connectivity to each other and receive support from back-end systems at a third location, the WERCware operations center.

Although exact configuration of the WERCware system concept may vary depending on the consumer's disability and technology state-of-the-art, in general, communication between consumer and coach may be established using smart phones such as Android to maintain connectivity at both ends. The coach wears a headset for audio communication and views a video image which shares the consumer's point of view in his/her work or home environment, via an internet linked PC or tablet (see Appendix Figure 2). The coach may access an individualized consumer profile of context-relevant information including intervention scripts pre-entered in a database. The vision of WERCware involves other unique features: single provider multiple consumer (SPMC) time-sharing, recorded replay mode for review, biometric monitoring and privacy detection for automatic initiation and shutoff of the audiovisual feed, to augment manual mode between consumer and coach. Auto-documentation and time-management tools can help assess training outcomes and manage billing accounts.

While field trials for developmental work first focused on addressing participants with Autism Spectrum Disorders (ASDs), team members soon recognized that the need and potential market for WERCware extends to a broad range of consumers and providers, including adults with traumatic brain injuries receiving in-home attendant care, adults with intellectual disability receiving habilitation services, eldercare in own-home supported living programs, and others capable either of competitive employment or pursuant of more independent living. These consumers all stand to benefit from remotely provided services, making it more cost effective, while retaining the disability specific and individualized services of a single provider (i.e., social

coaching or attendant care). Meanwhile, the attractiveness of WERCware for social service providers includes the SPMC potential to gain economy of scale, auto-documentation to replace handwritten reports, and time management tools to streamline conventional social services in a completely new and innovative way.

Lesson#1: Keeping the big picture in mind helped project team members focus on what works to serve the consumer by effectively meeting the need, not just developing fancy technology.

Brief History of WERCware from Inception: Faculty/Student Involvement and Business Aspects

The following section describes the way WERCware provided a project platform for students to see how evolving technology could be shaped to meet consumer needs. Students who saw what was lacking in the ability of current technology to address the social need were inspired to investigate new advances. This runs counter to what happens in many cases where students are exposed to a new technology and wonder how it can be used.

In 2007, the Founder and CEO of SymBionyx, Curt Byers, who first envisioned WERCware, contacted the Collaboratory at Messiah College inviting us to partner in developing it. Having accepted the request, faculty resources, students, and lab facilities for project work was initially supported in 2008 by an Innovation Transfer Network (ITN) Seed Assistance Grant awarded to two faculty investigators: one with background in electrical engineering (Dr. H. Underwood) and the other in special education (Dr. N. Patrick). This funding and faculty partnership launched the multidisciplinary work. Summer 2008 grant research was conducted by two undergraduate students, one engineering major and the other psychology. Under supervision by the faculty and SymBionyx personnel, students performed a preliminary study on WERCware usability. As an outcome, the students drafted a job-coach training manual, assembled a proof-of-concept prototype, and gathered preliminary testing results from trials with neuro-typical volunteers acting as the consumer, and faculty volunteers taking turns serving as the coach.

As smart phone technology had not yet matured, the early WERCware prototype consisted of a relatively crude analog radiofrequency (RF) audiovisual link processed by analog to digital conversion for the feed from client to the coach via VLC (free open source VideoLAN media player), and a separate audio link via Skype from coach to consumer, transmitted by a fixed computer-to-computer internet link. This prototype became WERCware 1.0 (see Appendix Figure 1). While the rudimentary prototype tested in this study showed the functionality required to support remote job coaching, off-the-shelf wireless device technology unobtrusive and comfortable enough to be worn by consumers in the workplace had not yet emerged.

Following up on the 2008 summer research, two engineering students explored improvements to WERCware 1.0, as a focus of their project course sequence for their junior and senior years. Meanwhile, by 2009, a second grant proposal had been secured by SymBionyx from the Pennsylvania Department of Education (PDE) through the Capital Area Intermediate Unit (CAIU). The PDE grant funded a qualitative testing study in cooperation with CAIU #15 at its

Hill Top Academy. This study involved five high school student volunteers with Asperger's Syndrome (AS) participating in the role as the consumer, and five corresponding CAIU educational consultants taking turns in the role of coach. The two engineering students with faculty supervision provided technical support. Trials for each consumer (student) and coach were conducted once a week, over a five-week period during March 2009. Methods and results associated with this qualitative testing phase have been previously published.[5] Overall, students said they liked wearing WERCware, and completing tasks as instructed by the remote coach with it; the coaches agreed that WERCware was not only comfortable, but enjoyable to use for coaching. Such results encouraged the project team to continue its study, on a broader scale.

Lesson#2: The team first addressed a specific need in a smaller local market, and gradually worked toward the larger market, as recently suggested by a noted entrepreneur and author.[6]

By 2010/11, developments by engineering students in the engineering project curriculum had led to WERCware 2.0. This version consisted of an audio headset on which a stabilized camera was also mounted, both connected to a portable, pocket-sized FitPC. Previously separate client-side elements were now integrated, allowing the use of Wi-Fi from the FitPC as the wireless link, to support a Skype connection in both directions between client and coach. During these years, the faculty team was expanded to include a business faculty and another engineering faculty with prior experience managing larger budgets. Two attempts were made by the expanded team to secure a Federal grant through the Institute of Educational Sciences (IES), for funding a broader, more extensive study. While the experience of preparing the IES proposals served as a great learning experience for the team, the IES grant proposal reviewers in each case did not select our project for this kind of multiyear project funding. However, if the WERCware development team had relied on significant multi-year funding at this stage of the project, effective work may not have continued in the right direction. Continuing with smaller scope and hence smaller funding need allowed the team to make positive progress despite denied funding to expand.

Lesson#3: Grant or other sources of funding to further field testing proved most successful when the amount matched the size, scale and maturity of the project study/team.

Although the IES grant applications were not funded, ITN staff continued to work with the original co-investigators and SymBionyx partner, helping them refine a business model and network with interested parties. Rather than seeking multi-year sponsorship for the entire development effort, the revised goal was finding funding limited to the next needed stage of project field testing. Having a product ready to test and a well-defined field test program on the near horizon made it easier for donors to agree to participate. Also at this stage, technical efforts focused on selectively incorporating state-of-the-art hardware and software components that more fully embody the current WERCware vision (Appendix Figure 2).

In June 2011, the author of this paper was invited to present WERCware to a group of angel investors at an Engineering Forum hosted by ITN, as one of three grant-seeded projects in our

area deemed closest to commercialization. That presentation showed how Bluetooth-enabled smart phones could be used to provide a more unobtrusive communication interface between the participant (client) and a remote coach. Subsequent to the forum, representatives from Messiah College, SymBionyx, local investors and ITN staff participated in a series of meetings to explore how to further commercialize the idea. These discussions and other factors led to SymBionyx being transformed from a non-profit foundation to a for-profit company, as a way to better position it for taking WERCware to market. SymBionyx at this time also retained the services of DC-area-based The Alvarez Group as a strategic equity partner and consultant.

Field testing of WERCware 3.0 began in September and October of 2012. SymBioynx, with a team of students supervised by the original co-investigators, partnered with United Cerebral Palsy (UCP) of Central Pennsylvania in a successful pilot project using the latest prototype, including a wearable smartphone holster to enable remotely supervised training of a young woman with Down Syndrome in an Activity of Daily Living (ADL). The ADL study was designed to explore the ability of WERCware 3.0 to provide residential habilitation services to adults with intellectual disability. Research questions, methods and results of the ADL study were presented at the ITN Seed Assistance Grant Symposium[7] in November 2012. In summary: 1) WERCware performed adequately, 2) the consumer and attendant were enthusiastic in their support of WERCware and its perceived usefulness for their respective roles, 3) the consumer successfully learned a new skill with WERCware training, and 4) fluctuations in the effective bandwidth of cable internet service and 4G broadband proved to be a major technical challenge.

Lesson#4: A flexible concept / model of the system allowed for advances in state-of-the-art so as to incorporate new innovative features as those emerging technologies became available.

Developing a product with such far reaching potential as WERCware must balance trying to do many things at once with adjusting to changing opportunities. Shifting application areas and highlighting sub-components of the system gave students a chance to see how these two forces can be managed. As WERCware's benefits applied to Traumatic Brain Injury rehabilitation and in-home direct care services gained recognition, the scope for wider research and pilot project collaboration grew. While involving veterans and active duty service members has been discussed, in recent years, the focus shifted to developing and marketing WERCtymer, a software tool in the WERCware product family that emerged during the ADL study. WERCtymer times the performance of tasks being learned and counts prompts required to achieve a desired standard. WERCtymer enables capture, documentation, and graphical display of quantified progress in reaching target performance times and quality criteria. To date, such quantified effectiveness by clients and/or providers has been absent from disability services.

To facilitate funding SymBionyx on an appropriate scale, its original Founder and CEO turned over management to two full time professionals, a new CEO and a VP of software development, both with extensive experience in high tech start-ups. The new singular focus of SymBionyx became commercialization of WERCtymer as a first product module in the multi-component

WERCware system. This shift has resulted in a looser tie with Messiah College, as quality assurance versus product development became the critical path. Thus, the engineering team has opted to pursue research and development (R&D) issues, with no explicit delivery expectations.

Current Student and Faculty Research Related to WERCware

During the latest R&D phase, the line of inquiry has been inspired by needs identified during earlier field trials, overcoming other barriers of effective use and/or marketing. Thus, students have focused on Biometrics and Privacy Control. The research question related to Biometrics is whether sensor technology can be worn by the consumer that reliably detects human body signals uniquely preceding a negative human stress meltdown condition, so as to trigger an automated response or call from consumer to remote coach. Sensors and signals that have been explored to detect human stress include Galvanic Skin Response (GSR), microphone with Automatic Neural Network (ANN) speech processor, and an Electroencephalographic (EEG) headset. Biometrics research is ongoing, including efforts on the app development side.

Privacy Control research has investigated means of automatically shutting off the audio and video feed, when in the vicinity of a confidential area, as a backup in lieu of manual shutoff. To do this, the team has explored radiofrequency identification (RFID), nearfield communication (NFC), ultrasound, and other new off-the-shelf technologies such as Bluetooth beacons. The research is ongoing, with app development oriented toward selectively deactivating the audio and video feed connection to the coach when proximity to the confidential area has been detected. Engineering students in this R&D phase have concentrations in electrical and/or computer engineering, under engineering/math faculty supervision, and regular client input.

From the inception of the WERCware project to the present, meetings with either SymBionyx board members or the original visionary and CEO as the client representative and members of other partnering organizations have been frequent, at an average of once a week or two, according to overarching organizational parameters. Such client meetings have included face to face interaction during extended field studies, scheduled on-campus or off-campus consultations, design reviews and email exchanges. These meetings have enabled the team to update progress with interested stakeholders, get feedback, and stay in touch with client-defined needs, preferences and priorities. Client communication also helps better inform engineering members about cross-disciplinary constraints including social, ethical and legal issues.

II. Methods

Engineering Curriculum Parameters: Two Year / Four Semester Project Course Sequence

Previous publications addressed the competitive process by which students are selected on teams[8], and the way students are assessed[9] in our credited engineering project curriculum at

Messiah College. However, a few curriculum modifications have occurred in the last couple years that will be highlighted here. Recent modifications were motivated by a desire to simplify requirements, match assignments to project needs rather than academic assessment, and increase flexibility of the project scheduling structure. Reducing the documentation requirement has streamlined the assessment process, while incorporating agile project management has helped adapt the schedule for project task chunks in a more customized way, rather than as constrained by the academic calendar. While the portfolio approach[9] previously used for project assessment has now been eliminated, the rubrics developed for these portfolios were retained, with some revision, for continued use with the new project report / project record requirement. Project records, similar to lab reports, are completed by one or more individual students, to document details of individual project tasks. While multiple project records may be needed, only one overall project report per team is completed at the end of each semester. The project report serves as an overview to document total team progress; though more summary in nature, it ideally references individual project records for supporting details. These two documentation requirements expose students to 1) the need to record necessary detail from work performed on a project so that technical personnel can benefit and 2) the value of pulling the work of the entire team into an executive summary suitable for the consumer or funding agency.

Students officially learn the agile project management strategy in the second semester of their sophomore year, and practice by doing a sample short term project (one semester one credit). In this approach, students break down the accomplishment of a defined engineering problem into smaller more manageable tasks. The smaller tasks are prioritized for logical order as needed, and transferred either to sticky notes for placing on a whiteboard, or entered into an electronic teamwork task manager such as Trello. Overall objectives are established for the 6- to 9-week project segment known as the Minimum Viable Progress (MVP), based on the identified tasks. The scope of the identified tasks are ideally vetted by the student team using a bidding process involving a specially designed deck of cards with a range of numbers indicating hours required to accomplish the task. All members of the team keep bidding (guesstimating) the hours each identified project task will take, until sufficient agreement is achieved. This exercise makes it obvious to students that a clearly articulated task description is necessary for common understanding. It also helps students develop the skill to accurately estimate the time required for a range of different types of tasks. Once the hours for all identified tasks have been estimated, and tasks have been assigned to students, the total number of task hours is determined. The actual MVP review (end) date of this agile managed project period is determined as the total number of hours required for identified tasks, divided by the number of student hours committed per week on project work. For example, if a three student team each contributes 4 hours per week to project work, and the total task time is 84 hours, then the MVP will take 84 hours / (3 students x 4 hours per student per week) = 7 weeks. This duration is within the recommended 6- to 9-week window. If predicted MVP duration is less than 6 weeks, the team adds more tasks. If

predicted MVP duration is more than 9 weeks, some tasks should be put into the "ice box" to be taken up only if time permits (other critical tasks are done early) or left for the next MVP. At the end of each MVP, engineering faculty along with any external partners who have an interest in the project serve on a review panel for the project team. Student team members complete project records to be graded by faculty using a relevant rubric (from the aforementioned collection) and prepare a brief presentation; the presentation should demonstrate any new working pieces of their project, in a question and answer format with the panel. Such MVP reviews mimic a guided discussion design review rather than a more formal conference type presentation. Following the review, the student team is temporarily dismissed, while the panel by consensus assesses team progress and other criteria by rating items of the MVP rubric via a fillable electronic form. A portion of the score on this project status rubric serves as a presentation grade for the project course, but the majority of it contributes to the overall progress score which, depending on its level, results in a green, yellow or red overall status for the whole project team, rather than merely for individual students. This establishes whether the project is clear to move forward, needs intervention by organizational staff, or should end soon. One critical criterion for continuation is an ongoing relationship with an identified client. Policies regarding implications of the green, yellow, red status are made known to the students.

Project Course Grade Component Breakdown

In our revised and simplified approach, engineering project students are graded in three main categories: progress against plans (30%), reporting & documentation (40%) and contribution to project progress (30%). Progress against plans represents the same score of 0-30 assigned to all members of a project team by the responsible faculty member based upon MVP panel feedback and project-record reported work toward goals established in the MVP planning documents. Reporting & documentation involves: 1) a presentation part (10% of the 40%) with both team and individual aspects on MVP reviews, posters or symposium talk; 2) the project report (10% of the 40%) is the same grade for all team members; and 3) project records (20% of the 40%) as an individual grade for record authors on the details of work done. Project progress is assigned by the project manager based on assessment of the individual student's effort and achievements.

Feedback From Students: A Pilot Study Survey on the Lessons They Learned

Sample feedback from our Junior- and Senior-level engineering project students was obtained from a pilot study survey for 20 (18%) out of the total 113 students at the end of the Fall 2015. As a matter of practicality, only 20 of the 113 project were surveyed initially in this study, since the remainder met under different leadership in different locations. Students surveyed were involved in projects with long term, client-focused characteristics similar to the WERCware project described above. Of the 20 total students who took the survey, 12 (60%) were at the Junior level (1st semester of 4 semester sequence or P1), while the other 8 (40%) were at the

Senior level (3rd semester of 4 semester sequence or P3). This survey was administered in written form during the final exam period when these 20 students were in a common room after oral discussion of some other common issues. The written survey gave students a question with a series of possible response statements. The question was,

> *Which of the following would you consider to be a significant Lesson Learned so far, based on your experience with [the project curriculum at our institution]. Why?*

Students were instructed to rate eight possible response statements on a scale of 1-5 (where 1=totally disagree and 5=totally agree), with one open-ended option (*other: please specify*). After rating all the possible responses across the spectrum of agreement or disagreement, students were asked to add their own comments in words (in the space provided) on at least their top 3, illustrating their response with specifics, as much as possible. All feedback from students was voluntary; no particular credit was allotted to the activity as an incentive or disincentive. The results of this survey will be provided in summary form in the next section of this paper.

III. Survey Results

Results of the pilot study survey are provided here in the following way: identity of the top three out of eight possible lessons learned as judged by students from their experience, along with overall average ratings in Table 1 and illustrative comments by WERCware students in Table 2. For consideration as a possible lesson learned, students first read and rated the following eight statements as a response to the survey question above:

> *"I have learned how to…"*
>
> *1. "…work within the structure of a real organization, known as the Collaboratory [center for interdisciplinary project work at our institution]."*
> *2. "…do an engineering project to serve the needs/specifications of a real client."*
> *3. "…do an ongoing engineering project that lasts for more than one semester."*
> *4. "…work on an interdisciplinary project effectively as a team with other students who have different concentrations or major disciplines."*
> *5. "…estimate and manage my time spent on doing particular tasks for the overall benefit of the project and team."*
> *6. "…communicate more professionally and effectively with partners and clients who live and/or work outside of the academic community or geographic area."*
> *7. "…live out my beliefs and understanding of what it means to be an engineer so as to get a clearer sense of my perceived calling in my life and career."*
> *8. "…a) better understand the needs of the poor and disadvantaged and/or b) work within constraints of a limited budget to choose between technical alternatives."*

The summary of student ratings of the top three responses followed by responses to the remaining options appears in Table 1 below.

Table 1. Rank and ratings by project students in the pilot survey for possible response statements to the survey question as indicated above.

Response Statement Item Code	Overall Rank	Overall Average Rating (N=20)	Junior (P1) Avg. Rating (N=12)	Senior (P3) Avg. Rating (N=8)	WERCware Team Avg. Rating (N=3)
1	2	4.3	4.3	4.25	4.3
2	3	4.2	4.3	4.1	4.3
3	1	4.3	4.3	4.3	5.0
4-8	4-8	3.5	3.3	3.8	3.5

For further illustration, comments on the top three lessons learned by students on the WERCware team, though not necessarily representative of others project team members, appears in Table 2.

Table 2. Comments by WERCware students to illustrate the top 3 response statements.

Response Statement Item Code	Student #	Comments
1	1	It was interesting to actually work for an organization. It gave me a chance to see the upper workings of such an organization.
	2	MVPs illustrated giving an update to upper management within a business.
	3	Project planning and meeting with an outside professional were helpful by simulating the type of work done in the real world.
2	1	Having to work with a client helped to understand how a project may change depending on the client's ideas for the project.
	2	We met with the client regularly. He enlightened us to how our project will have a huge impact on the people we are serving.
	3	Our current client has helped us to define what the project flow should be and we worked to meet those needs.
3	1	It helped to go through a semester working from previously done work and needing to account for future work.
	2	We had to look at previous project records and field to learn what had been done and where a previous team member stopped in their work. Sometimes we even needed to email them to [have them] explain things about their specific work.
	3	It is a lot harder to work on long-term project like this because it is sometimes hard to see the project ever ending. This experience helps me to understand that it is okay to make little overall progress while doing tasks that are extremely important to the smaller portions of the project.

IV. Analysis and Discussion

Ratings from the Results section in Table 1 for the 20 project students in this pilot study survey show the three top response statements about lessons learned at nearly the same average overall (~4.3), but significantly above the overall average (3.5) for the other five suggested options. On a scale of 1-5 where 1=totally disagree and 5=totally agree, the overall average rating of 4.2 or 4.3 may be interpreted as somewhere between somewhat agree and totally agree. These ratings suggest students perceived themselves as having learned to do an engineering project to serve the needs/specifications of a real client, as an ongoing project that lasts more than one semester, and to work within the structure of a real organization. As a procedural issue, it should be noted that these were the first three possible response statements on the survey, under the instructions on the first page of a two-sided survey sheet, while the other response statements were all on the back side. Such ordering and the layout of the survey could have unduly influenced student opinions as registered here, and in the future should be laid out more carefully.

When the average ratings on each of these response statements is separated between Junior (P1) and Senior (P3) students, not much variation in the averages is noted. This is in spite of the fact that the P1 students have completed only a single semester of work, while the P3 students have completed three semesters of work in the formal project curriculum. One might have expected the P3 students to have rated the response statements more highly if their more extensive experience gave them a greater sense of having learned the lesson. However, this is not borne out in the data. Some of our project students have had more experience with the ongoing project work than is suggested by the formal credited P1 or P3 designation, if they volunteered for project work during their first year at our institution. We consider students who volunteer for the project work before entering our credited engineering project curriculum as doing a valuable internship with our multidisciplinary project organization. This is deliberately quite analogous to students who do a pre-graduation internship with an off-campus company, and if mutually agreeable, may continue to work for that same company after graduation.

Considering the specific survey results of the three WERCware students, it is clear that their ratings were either at the overall average of others, or well above it, as is the case for the statement about learning to do ongoing project work that lasts more than one semester. All three of these students were engineering major Juniors (P1), one with an electrical concentration, one with a computer concentration, one with an electrical/computer double concentration. Two of these three students had previously volunteered on the same project during the prior full academic year. Thus, these two students had more experience with details of the WERCware project and agile project management method than the typical P1 student. Specific comments by the three of these students reveal 1) how they perceive the importance of communicating with, scheduling appointments for, and having the influence of the outside client on the project work, and 2) the challenge of doing ongoing project work which requires finding, reading and understanding what previous students have done (even if documentation had not been great), keeping smaller tasks in perspective with the bigger picture, and planning for future work.

Working as an engineering faculty advisor, principal investigator and project manager over the past eight years on WERCware has also been a valuable learning experience and significant professional development opportunity for this author, much more than advising the former once-and-done senior capstone projects typical of our previous undergraduate curriculum. The ongoing multiyear project curriculum encourages continuity of focus, with opportunities to develop long-term relationships while working toward meeting and satisfying real community needs. Learning to address the social need of those with high functional autism and other cognitive and behavioral disabilities brings the technology in a unique direction (e.g., exploring Biometric sensors to select the best combination for detecting negative human stress to predict risk of "meltdown" situations, and the necessity of a backup automatic shutoff/disconnect to the remote coach in confidential areas for ethical and legal reasons); adapting presentations to the business issues considered by investors takes entrepreneurial spirit, resulting in a broader multidisciplinary venture than a purely academic engineering project would otherwise be. While the multidisciplinary venture of engineering improved social services brings significant faculty professional development benefits, its educational value for undergraduate engineering students serves them well as preparatory experience for entering the marketplace upon graduation.

V. Conclusions and Future Work

This paper has reviewed eight years of experience by a team of faculty and students developing WERCware to provide social services; several lessons have been learned along the way. These lessons may also be instructive to other engineering faculty who manage or advise undergraduate engineering projects. To recap, four key lessons learned by the team phrased as suggestions here include 1) keeping the big picture in mind to helps project team members focus on what works to serve the client by effectively meeting the need, not just developing fancy technology, 2) when developing a new product, it helps to start by trying to meet a specific need in a smaller local market, and gradually work toward the larger market, 3) grant funding or other support for field testing proves most successful when the amount matches the size, scale and maturity of the project study/team, and 4) a flexible concept/model of the system allows advances in state-of-the-art so as to incorporate new innovative features as those emerging technologies became available. Without the visionary, motivational influence of our non-engineering client on the WERCware project over the years, engineering team members would not have been so inclined to cross traditional disciplinary boundaries, so as to "think outside the box."

Based on a number of possible options offered to students in a pilot survey of all our current project students, three lessons students say they are learning from the experience of working on projects in our undergraduate multiyear multidisciplinary engineering curriculum include 1) how to do an engineering project to meet the needs/specifications of a real client, 2) how to work on an ongoing engineering project that lasts for more than one semester, and 3) how to work within the structure of a real organization.

This study, and the progress made by the WERCware team reveals a few areas for future work, such as 1) developing a more carefully formulated and extensively distributed survey (e.g., for the whole group) of our project students to assess their perception of lessons learned, 2) investigating why students are not perceiving themselves as having learned some other lessons in their project work that we consider to be important, and 3) networking to help advance further progress on the research with Biometric Monitoring and Privacy Control as related to more effective delivery of social services via WERCware.

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References

1. Barrett, S., et al., "Service Learning: Assistive Technology Undergraduate Design Projects," *Proceedings of the 2012 ASEE Annual Conference*, San Antonio.
2. May-Newman, K., et al., "Senior Design Projects in Assistive Technology: Opportunities for Technology Transfer," *Proceedings of the 2007 ASEE Annual Conference*.
3. Jouaneh, M., et al., "Assistive Technology Devices: A Multidisciplinary Course," *Proceedings of the 2004 ASEE Annual Conference*.
4. Dave, J., et al., "Remote Assistive Elevator Control Device," *Proceedings of the 2003 ASEE Annual Conference*.
5. Underwood, H., "Assistance for Asperger Syndrome from Communications Technology Developed through an Integrated Projects Curriculum," *Proceedings of the Spring 2009 ASEE Mid-Atlantic Section Meeting,* Loyola College, Baltimore, MD.
6. Thiel, P. and B. Masters, "Zero to One: Notes on Startups, or How to Build the Future," Crown Business, New York, 2014.
7. Patrick, N. and C. Byers, "Prototype Development of the Wireless Enabled Remote Co-presence (WERCware) from Idea to Market: A Case Study," Seed Assistance Grant Symposium, November 16, 2012.
8. Underwood, H. and D. Pratt, "Competitive Placement of Engineering Students on Multiyear Project Teams," *Proceedings of the 2014 ASEE Annual Conference*, Indianapolis.
9. Underwood, H., "Using the Portfolio Approach to Assess Multi-year Engineering Projects: A Case Study," *Proceedings of the 2013 ASEE Annual Conference*, Atlanta.

Appendix: diagrams for further illustration

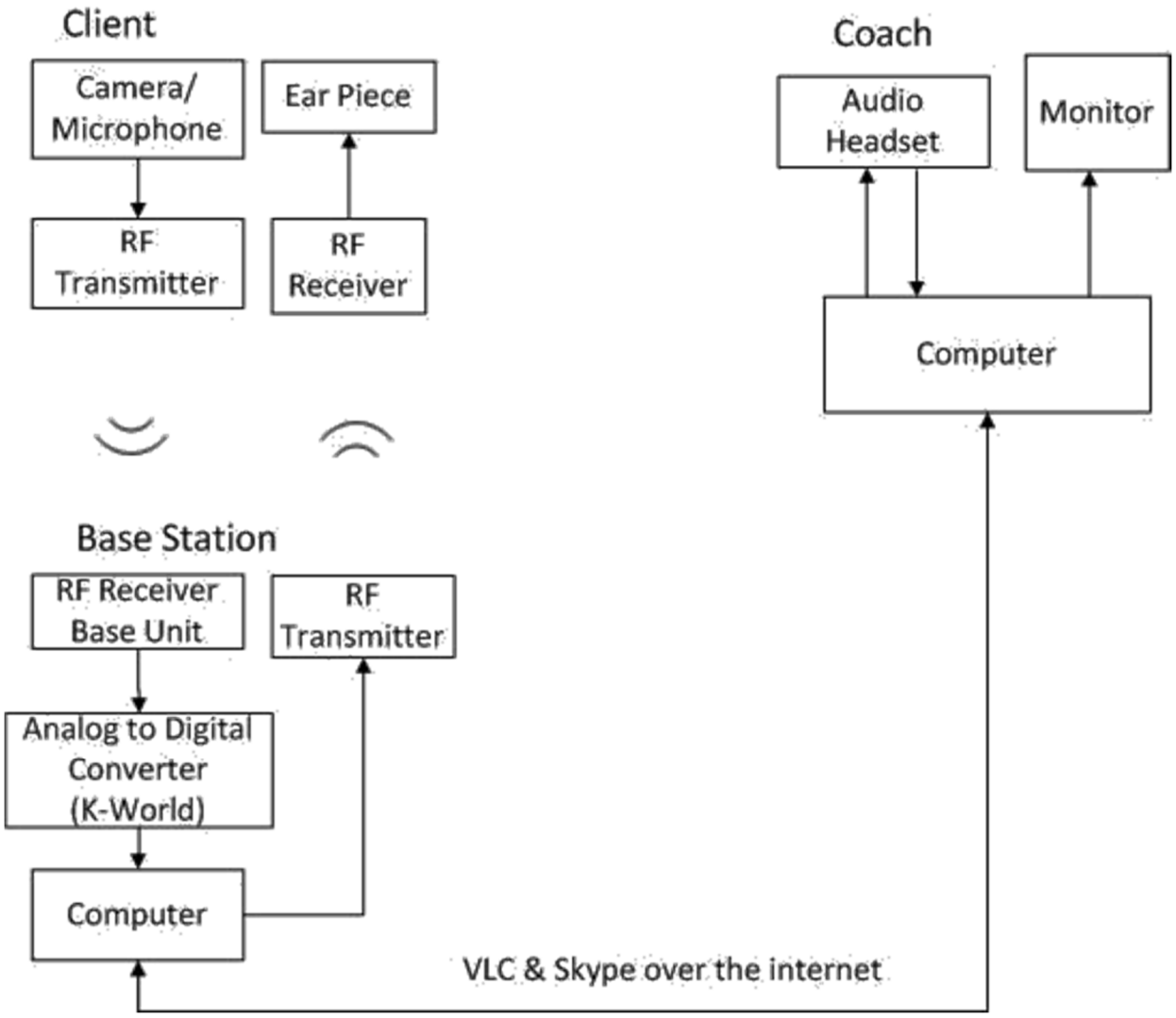

Figure 1. Block diagram of original architecture for WERCware 1.0 prototype.

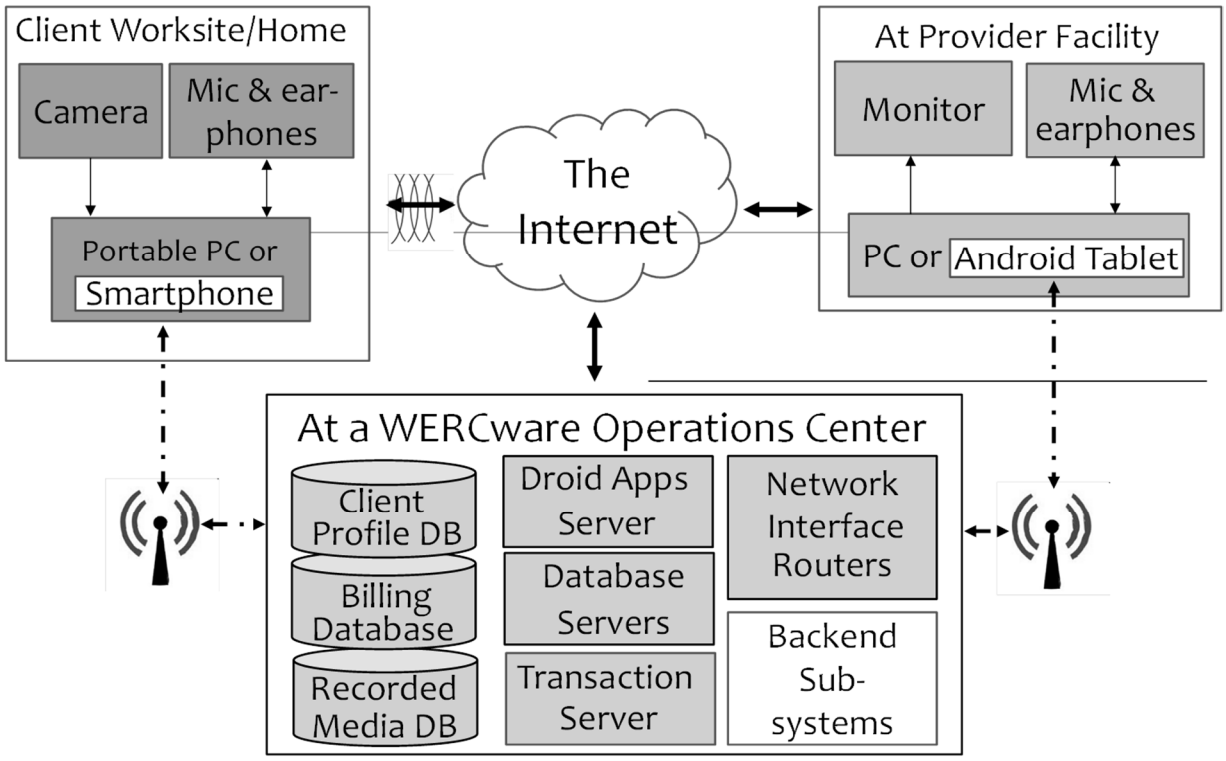

Figure 2. WERCware System Block Diagram including client side and provider side technology for Vocational Rehabilitation job coaching or In-home attendant care.