Smart and Connected Health Apps: A Cross-Disciplinary Effort

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Mr. Francis Xavier McAfee, Florida Atlantic University

Francis X. McAfee, Associate Professor in the School of Communication & Multimedia Studies at Florida Atlantic University (FAU) merges his background as a ceramic sculptor and printmaker with new digital technologies. After graduating with a BFA in Art in 1989 he joined the Florida Center for Electronic Communication (CEC) as a lead artist creating animation for applied research projects. These computer animated films were nationally and internationally screened in New York, Chicago, Hollywood, San Francisco, and Tokyo in industry recognized competitions as the International Video Art Competition, the New York Festivals, and the American Film Institute.

McAfee is also active in web-based virtual reality projects. His research includes digital archaeology of a deteriorating ancient tomb in Sicily to help preserve and visualize its' characteristics for future study. His collaboration with Florida International University's International Hurricane Research Center showed how certain roof construction materials may become projectiles during high wind events. For the FAU Center for Environmental Studies' Sea Level Rise Summit McAfee lead a student team to produce a short animated video showing what might happen to the neighborhood around the Miami Freedom Tower if sea level rises to its full potential impacts. The video was picked up by National Public Radio and other media outlets. In 2007 he helped visualize the research of FAU's Ocean Engineering using animation for a competition for a State of Florida Center of Excellence. FAU won the completion and has since been named as a national research center, Southeast Regional Marine Renewable Energy Center. Since 2009 he has collaborated with colleagues in Computer Sciences and other colleges to form cross-disciplinary student teams that create software applications for Android mobile devices.

McAfee compliments his professional activities with volunteer service for ACM SIGGRAPH. He served on their executive committee as Director for International Chapters and has organized local Fort Lauderdale chapter events for over 20 years.

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Abstract:

Engineering undergraduates may not have full appreciation of the potential impact of technology on health care, currently one-sixth of the US GDP. Technology has a major role to play in reducing health care cost. We focus here on building smart phone apps for patients to use at home to manage their health care. This will reduce the number of patients' visits to hospitals, length of hospital stay, and the stress of a hospital visit.

Eleven teams of engineering, nursing, and arts students were brought together to develop such smart phone apps for health care. Different teams focused on different aspects of the app eco system, viz., interfacing biosensors to the smart phone, augmented reality on smart phones to help the patient visualize various procedures/exercises, and cloud-based data and trend analyses to help communicate with medical professionals and/or seek additional information online. This initial experience has helped us build an integrated ecosystem that uses only one programming language (JavaScript) that also is very popular and easy-to-learn. Future course offerings will leverage this.

We hypothesize that such a transdisciplinary collaboration will not only increase awareness of health care challenges and solutions among mainstream engineering students, but also pave the way to recruit and retain women and underrepresented minority students in engineering. Social science research has shown that framing engineering tasks in terms of real-world problems and narratives would help enhance engineering identity among women and underrepresented minority student groups. The current mainstream engineering students taking this course will also benefit as they will get exposed to challenges in the healthcare industry, learn to communicate and collaborate with non-engineering majors, and apply their knowledge to solve real-world problems.

Background:

We document here our experiences in developing smart phone apps for healthcare with teams of college students from multiple disciplines across colleges. This builds on our experiences in bringing together faculty members from different disciplines to teach their respective students both discipline-specific material (during the first half of the semester) and mentor them with regard to collaboration across disciplines (during the second half of the semester). Our focus here was to develop healthcare apps that will empower patients to monitor, manage, and/or communicate with their physician. The first goal requires interfacing to home-based biomedical monitors; the second goal will need access to the web and individual/community healthcare data; and the third goal would want a backbone or infrastructure that mimics (on a small scale) the EMR (electronic medical records) found in hospitals. It also required engineering students from electrical engineering, computer engineering, and computer science / information technology, to tackle different sub-engineering objectives. Thus, each group had 3 engineering students,

typically one each from these three engineering disciplines, randomly assigned to each group. In addition, the student teams had a nursing student to ensure that the app had appropriate health content, and an arts student to ensure that the app had aesthetic appeal and a user-friendly interface. The teaching and mentoring involved 3 faculty members (co-authors of this paper), one each from engineering, nursing, and digital multimedia. We could undertake such an ambitious project since we have addressed the various sub-aspects of transdisciplinary collaboration in our previous course offerings (Donate et al., 2015, Shankar, et al., 2017a). All the Apps are published as public repositories at a Github site (GitHub 2016). They are available for free download.

Our efforts are driven by a desire to enhance engineering identity of our engineering students, to expose our engineering and other non-engineering students to each other's disciplines and knowledge perspectives, to help all of them to learn to work across disciplines for a common goal, and to become, in the longer run, responsible citizen of the society. The last perspective is important since no current societal problem/challenge can be solved in isolation, and requires concerted effort across disciplines. We bring together concepts of formal and informal learning into the process to make the experience more student-centric (each team chose their own app topic, from a given set of topics) and flexible (our students came from two different campuses and multiple sections of an online distance learning course). Our goal was to build the full infrastructure for future course offerings; and as such, about one-third of the teams each focused on bio-system interfacing, augmented reality, or cloud computing.

We collected several formative and summative measures. We sought pre and post-surveys of all the students to appreciate better their acquisition of soft (team) and hard (technology) skills. These were self-reported and voluntary. Results show significant improvement in multiple dimensions. The three faculty members involved judged the presentations at semester end, to provide relative rankings for grading purposes.

Once the infrastructure is developed, it is our intention to utilize it to enhance retention of women and underrepresented minority students in engineering and to encourage more engineering students to undertake such transdisciplinary projects for their capstone design project in their senior year. Research studies will be set up to pursue these studies. Another similar study, documented at this conference, provides more details on this future research endeavor (Shankar et al., 2017b).

Rationale - A Health Sector Perspective:

Health care cost has skyrocketed to 17% of the US GDP. Americans are not living longer and happier as a consequence of this stepped up cost. The US government has launched several initiatives to improve health care. This paper addresses a missing link, viz., building an infrastructure to record patient's health in their homes, where most time is spent. Medical professionals can then track this data to improve patients' health (patient empowerment is a longer-term goal). This will reduce the number of patients' visits to hospitals, length of hospital stay, and the stress of a hospital visit. We have developed such mobile health care apps with a cross-disciplinary collaboration that involves students and faculty members in engineering, nursing, and multimedia.

This course involved 3 faculty members, one each from engineering, nursing, and multi-media, who taught their concurrent courses in the three disciplines, to a total of 50 students. Eleven student teams were formed with participants from all the three areas. App topics ranged from 'Motivational Phrasing for Depressive Symptoms' to 'Healthy Heart' to 'Caring for Others.' During the first half of the semester, we covered material that is team-project relevant, but discipline-specific. Student teams then focused on developing their App. Engineering students focused on functional development and on one of the three healthcare related additions (hardware interfacing via e-health shield to biosensors, augmented reality as a counseling tool, or cloud interfacing to electronic medical records). Nursing students provided content and ensured that the app was relevant and useful to the health concern chosen. Arts students ensured that the app was user friendly and pleasing. Faculty members brought together these students for initial introductions, team formation, progress reports, and final app presentation at semester end. The faculty members scored the teams with a rubric for nine app attributes. The rubric was based on a five point Likert scale, as described later under the research section.

This project brought together STEM and non-STEM students of both genders in teams, thus reaching a large and diverse community. All our apps are published for free access as Github repositories. The app development process would also be useful to faculty members elsewhere. Such Apps can become the conduit to recruit patients for faculty initiated research studies. Data collected then will be available and current, and bound only by privacy concerns as postulated in the institutional research protocol and as consented to by the patients. This research avenue is all the more important given the rapid advances in epigenetics and their positive impact on personalized medicine.

The Reference section lists many medical and health related publications that provide the rationale for undertaking this effort. We provide here a summary overview. An early impetus for this came from the Institute of Medicine (IOM, 2001) in a report that addressed the ills of health care delivery in the US. Bonow et al. (2005) addressed the disparities in health care delivery specifically in the cardiovascular area, the leading cause of death in the US. Over the years, this has spawned explorations in two areas relevant to this paper: (1) behavioral research to improve health care; and (2) utilization of technology to improve delivery of health care and to empower the patient. We refer here to certain key behavioral research papers that address the role of nursing and social science professionals in behavioral modification of patients (Bodenheimer and Handley 2002 and 2009, Glasgow et al. 2004, and Piat et al. 2010, AHA 2013). Current thoughts and tools for behavioral scoring systems are also referenced (Horsman et al. 2003, Rollnick et al. 2008, and PROMIS 2015a and 2015b). Progress on the technology front is seen in the open source launch of VistA (see VistA, n.d.) which is based on the Veteran Administration's electronic medical record (EMR) system, considered to be one of the most sophisticated EMR systems in the world. Analytics of massive patient data collected (subject to patient privacy and security constraints) has yielded many useful insights (JASON 2014, NAE 2005). All this has led to federal, academic and industry publications that have identified the benefits of collaboration between engineering and medical professionals (NAE 2005, NRC 2009, CCC 2010, and IOM 2011).   NSF and NIH have taken the lead in identifying Smart and Connected Health as a joint research and development initiative (NSF, 2017). See also (PCAST

2010, Pavel 2010). This is bound to increase interest and interaction among the two professional disciplines.

The above paragraph lays out the rationale for the need to develop apps for helping patients to monitor, self- manage, and communicate with their caregiver. A good example is the App for Thyroid Cancer patients, developed in Lingras' book (Lingras, 2016). The platform-independent smart phone app supports client-server architecture with interfacing to a NoSQL database at the back, all written with JavaScript. The patient can enter his/her signs and symptoms, and lab measurements. They are all uploaded to the cloud database. Trends can be plotted with visual display of the current severity of the disease. Links can be provided to reliable online data sources. The patient can also be connected to the EMR system of his/her healthcare system, so physicians, nurses, pharmacists, and health insurance companies can get involved in rapid and personalized health care delivery to that patient.

The Learning Perspective:

We cover below the applicable theories and models in formal and informal learning, and the applicable research questions. Our group has explored many avenues to help improve engineering enrollment, retention, and graduation, at various levels of K-12 and college education. This is especially relevant for our highly diverse community (both at the local and national levels), since literature review (given below) shows that value beliefs drive motivation for groups that are underrepresented in engineering. This is one of a few papers submitted to the ASEE conference by our group. Each paper addresses a different aspect and a different type of student group, but there is some commonality in the methods, theories, and assessments used (See Donate et al., 2015, and Shankar et al., 2017a and 2017b).

The application domain chosen here specifically is health care in the informal setting. We wish to use this to achieve several goals: (1) Redirect our engineering students' efforts to seek jobs beyond the traditional high-tech and information technology sectors. We would like them to realize that there are many other areas for their productive involvement. In fact, the healthcare industry has significantly more potential for both jobs and financial return (risk is higher because technology has not been fully embraced in the field, leading to potentially higher returns); (2) Motivate underrepresented minority (URM)   and women students to enroll and persist with engineering. It is our hope that exposure to various fields, such as health care, virtual reality, and social and community issues, will help non-dominant groups to find a home in engineering and thrive; and (3) Help our engineering students interact with fellow professionals from other fields to appreciate better others' perspectives, and to collaborate and innovate.

Persisters and Non-persisters in Engineering:

Recent push to increase enrollment, retention, and graduation of STEM graduates has led to many research studies to identify the characteristics of those who graduate in engineering ('persisters') and those who leave engineering majors ('non-persisters'). Matusovich et al., (2010) undertook to understand how and why students opted to enter and persist in engineering. Persistent rates of engineering students are similar to students in other disciplines; however, engineering has a gender gap, not seen in other disciplines. Thus, their study is all the more

important to build a large and diverse community of engineers. They used motivation theory of Eccles, called expectancy-value theory to explain persistence. Eccles' theory factors in gender and ethnic differences in STEM participation (Eccles, 2005). They hypothesized that educational, vocational and avocational choices would be most directly related to person's expectations for success and the value they attach to the available options. Simply put, the Eccles' theory suggests that choices to engage in activities are shaped by competence and value beliefs. Competence is about acquiring skills and applying them. Competence beliefs have been studied more widely than value beliefs among K-12 and engineering students. They are mostly based on the self-efficacy theory (Bandura, 1997). Self-efficacy is enhanced by positive feedback, better performance, and social comparisons. Value beliefs, on the other hand, have not been that well studied. Whereas competency beliefs look at a person's ability to engage in an activity, value beliefs consider the desire and/or importance of engaging in the activity.

The value system refers to one's own personal importance for the task. Matusovich et al (2010) addressed it this way: how do engineering students' engineering-related value beliefs contribute to their choices to engage and persist in earning engineering degrees? The Eccles' theory covers four value categories: interest, importance, cost, and attainment, to describe how individuals assign importance to engaging in an activity. Matusovich et al developed operational definitions for the value categories as follows: Attainment refers to a reason for pursuing (or not) engineering that is related to the self-perceived identify of an engineer; Cost is the price of success (or failure) in terms of effort, time, and/or psychological impacts in pursuing engineering in comparison to another career; Interest is the enjoyment (or lack of) experienced in doing engineering activities; and Utility is the perceived usefulness (or lack of) of becoming an engineer and/or earning an engineering degree (Matusovich et al., 2010). The authors conducted longitudinal semi-structured interviews of 11 participants (5 men and 6 women) during their four years of undergraduate engineering education. They found that all four Eccles' value categories are present; that attainment value plays a prominent role, but not an exclusive role, in participant's choice to earn an engineering degree; and that the four categories are not mutually exclusive. In summary, the researchers found that participants can be categorized with high or low engineering-related attainment values. Participants with high attainment values have low cost values, moderate to high interest values, and moderate utility values. Participants with low attainment values tend to have moderate or high cost values, low or moderate interest values, and moderate or high utility values. The one female student who left the engineering program and opted for the teaching profession had low attainment value. Though the study is inconclusive on persistence (due to the small sample size), the study suggest a need to increase students' attainment values related to engineering in order to increase persistence. That is, "we can encourage students to stay in engineering by helping them associate a perceived engineering identity with their personal identity and demonstrating the value of this association. We must help students understand what it means to be an engineer not only by teaching a variety of engineering skills, but also by exemplifying the breadth of activities engineers perform in their daily work." Further, lower attainment values are seen among women along with greater uncertainty about engineering and engineering abilities found in them, despite their higher grades and persistence; this suggests it is very important to develop interest and competence beliefs in women to recruit and retain them in engineering fields.

Potential for Informal Learning:

We consider our approach as a combination of formal and informal learning. Our engineering students had to interact with students in nursing and digital arts outside the class environment, to build their app. As part of the curriculum, we scheduled four Face-to-Face (F2F) evening (non-class room) sessions where students from all the disciplines came together to discuss and present their app development progress. More details may be found in other papers from our group (Donate et al. 2015 & Shankar et al. 2017a and 2017b).

Research Design:

Our approach is derived from two theoretical models with strong emphasis on student involvement in the learning process: active student engagement (ASE) and project-based learning (PBL). Both approaches assume active student participation in learning practices where exchange of ideas, extensive interdisciplinary collaboration, and synergies are essential.

This research tests the hypothesis of a relationship between students' knowledge construction experiences and their STEM recruitment and retention rates. Research suggests that assessment and more specifically formative assessment where well-structured and sensitive feedback is provided to students can increase their self-belief and subsequently improve retention rates (Rust, 2002). Increased academic performance and competence (Tinto 1993, 2006) and "learning effects" (Prussia and Weis 2004) are found to improve student confidence and integration in the academic environment thus reducing attrition tendencies. We test a hypothesis that student learning outcomes will improve. We consider this as evidence of student success, affect, and retention rates.

The main goal of this study is to understand how interdisciplinary instruction affects students' ability to identify, formulate, and solve problems, function on multidisciplinary teams, engage with contemporary issues, communicate effectively in writing, verbally and visually, develop appreciation of the impact of planning and engineering solutions in a variety of societal contexts, and develop understanding of their professional and ethical responsibilities. Soft skills, such as communication, team spirit, leadership, sociability, time management, documentation, presentation, ethics, negotiation, etc., are all critical in successful delivery of a standout App. Our survey questions cover these aspects in a succinct manner.

Evaluation Design for Informal and Formal Learning:

There are a number of designs that can be used in the evaluation of one's program or project (Friedman, 2008). Regardless of the evaluation design, a 'logic model' is a very useful tool to clarify the goals of the evaluation and the project as a whole. Below, we define the logic model in terms of its generic components and include our specific components in parentheses: (1) Intended audience (transdisciplinary student groups) (2) Inputs - funding/in-kind contributions that are brought to a project (we have had funding from a local medical devices company and our university that supported this effort); (3) Activities - action undertaken to bring about desired ends (in our case, smart phone apps for healthcare); (4) Outputs - the immediate results of an action (Github repositories in our case); (5) Outcomes - the changes that show movement toward

achieving ultimate goals and objectives (In our case, the number of seniors who are better informed, prepared, and skilled to address health care technology challenges); (6) Strategic Impact - steps taken by individual projects to 'improve theory or practice through approaches, strategies, findings, or models having impact on the institutions or systems that promote informal learning." (The intent is to leverage the Integration of formal and informal learning to motivate URM and women students to see value in their engineering education); and (7) Contextual factors, i.e.., conditions that facilitate and/or hinder the extent to which the project learning are transferrable. (Iterative improvement is also implied in one offering to the next. Based on student experiences, we have now moved to a platform-independent methodology that can seamlessly integrate all the objectives we have had for this course. See Lingras (2016)).

Our evaluation is based on pre and post-surveys for self-reported improvements by students, formative assessment via student presentations to a group of professionals (in this case, the three faculty members involved), and summative assessment of student performance based on their course work in the three concurrent courses. This paper documents the results of pre and post surveys only. Formative assessments are typically done in our courses by a group of working professionals who represent all the disciplines represented in our endeavor. This was our first time offering a course with this combination of disciplines (and hence has no feedback from a group of external stakeholders). As an update, we have, since the submission of the abstract, offered this course twice. However, it was offered to only engineering students, and with a platform-independent app development methodology. Feedback from all students convinced us to seek a simpler and better integrated app development process. We now feel comfortable in offering full-fledged transdisciplinary courses in spring 2018, at which time formative evaluation will be undertaken (see the discussion section). We document our efforts at formative evaluation in another paper submitted to this conference (Shankar, et al., 2017a). The third part, summative assessment, was used to ensure students are making adequate progress in their skill acquisition (by assigning target specific assignments) so their team will be successful in their effort to build an app.

Methods:

Prior Research - Multidisciplinary App Development: Over the past six years, approximately 210 of our engineering undergraduate students have worked with 140 students from other disciplines (arts, anthropology, urban planning, K-12, nursing, and business) in developing about 55 good smart phone apps, most of them relevant to the community, citizen science, empowerment, and health care (Donate et al. 2015, and Shankar et al. 2017a). Students have worked in interdisciplinary teams of 3 to 8. Typically 3 or 4 faculty members from these various disciplines (one each) offered a course for their students. These courses were arranged to cover team-project relevant, but discipline-specific, material in the first half of the semester. During the second half of the semester, student teams focused on developing an app, while also learning advanced concepts in their disciplines. Faculty members brought together these students for initial introductions, team formation, progress reports, and finally app presentation at semester end. An App portfolio (comprised of assets, code, slides, video, and documentation) was uploaded to an open source site, so it is available for all future students (As examples, see Github, 2016 and MODS 2016). The apps were judged by a group of professionals and community leaders at semester end. The judges scored the teams with a rubric for nine engineering and non-

engineering attributes. The top four teams were invited to present/demo their apps at the semi-annual conference of a local high technology consortium (MTC, 2008). We highlight below some teaching and research projects.

Urban Planning Apps: As a pertinent example, during fall 2013, 33 undergraduate students in computer engineering teamed with students in urban planning (11) and arts (6) to explore domain-specific applications related to environmental issues and sustainability (Donate et al., 2015). Three simultaneous courses were taught by three professors, one each from engineering, multi-media, and urban planning. More details are available in Donate et al. (2015).

Apps for High School Students: We document in another paper submitted to this conference our app development experiences with high school students who came to our university for a summer course after spending 9 months as interns at our partnering science museum (Shankar et al., 2017a).

Research and Development on Team Skills: In earlier course offerings that involved arts, business, engineering, and anthropology students, the anthropology students acted as team-embedded ethnographers to learn about cross-cultural issues and recommend solutions. One of them, a graduate student, also monitored the faculty team.   According to the reports generated by them, misunderstandings were common because of differences in their disciplinary languages, tools, physical models, and skill sets, and also in terms of mental models of other disciplines and stereotyping. Reflecting on this experience, we have been able to develop procedures and tools that have reduced some of the uncertainty and friction. One example of a tool is a semantic web tool to help team members to get informed about each other's roles and disciplines (Donate et al. 2015).

Current Course Offering:

Thirty three engineering students from computer engineering, computer science, and electrical engineering enrolled in this elective course on app development. They were recruited with clear indication that they will be working with students from nursing and arts, and that, depending upon their skill set, they may be undertaking a project with emphasis on interfacing to a bio sensor (either electrical or computer engineering students), on uploading to an online electronic health record (either computer engineering or computer science students), or providing augmented reality (computer science students). Eleven teams were randomly formed by the engineering professor. They then communicated with their nursing (11 students) and arts student (6 students, with each of them supporting two apps) colleagues to finalize on a topic of mutual interest and on one of the three engineering sub focus areas, depending on their ability as a team to deliver on. For example, some multimedia (arts) students were already conversant with AR. The focus and content of the topic was decided in consultation with the nursing partner, with the arts student   providing aesthetic support. We found that some students had background in more than one field and that helped improve team dynamics, and fill the roles when one of the partners failed to participate in a timely manner. Students started communicating after week 3, but focused on discipline specific learning for the first 7 weeks. App development was started in earnest after that, while professors covered more advanced topics in the class. Four F2F sessions were held to help students get introduced to each other, develop a story board, make an interim

presentation on the app developed, and finally make a 15 minute presentation at semester end on the final product. All the documentation, presentation, video (links only), and code files were uploaded to a Github repository (GitHub 2016).

Technology Details: Students developed Android Apps with Android Studio 2.0 (Smyth, 2015) on Nexus 7 (2012/ 2013) tablets (secured with a grant by the professors involved). Biosensors supported by the e-health shield platform (e-health Shield, 2014) were made available to students, thanks to a Tech Fee grant from the university. These are low cost Arduino-based platforms that support typical biomedical sensors, with the acquired biodata conveyed to the smartphone via Bluetooth. Students chose digital biodata to track and upload, since analog biodata (such as ECG) would have required skills in digital signal processing. Parse.com was used to provide cloud data storage and analytics via JSON. However, Parse.com has stopped supporting the free tier. Our students since then have migrated to AWS (Amazon Web Service) which provides a free tier. It is flexible and can be customized to meet one's needs. AWS has a good university program. Augmented Reality was facilitated via Vuforia (n.d.) and Unity -3d (n.d.) software tools. Both have good university programs and make available their tools free to students. A local company also worked with us to help the engineering and multi-media professors, as well as some of the students, to get up to speed quickly. We were able to install an open source EHR system (VistA, n.d.) thanks to a very active open source community, viz., WorldVistA (Vista, n.d.), but were not able to use it in that semester's team projects because of a missing JavaScript interface. A side note: We have since then developed the interface, in collaboration with the open source community. As such, our future course offerings will benefit from the new cloud infrastructure that is comprised of AWS and VistA. We have also developed a platform-independent methodology so our apps can run on all smartphones, not just Android OS-based ones (Lingras, 2016). Our first repository with this new methodology is available here (FAU Mobile Apps, 2016).

All students took a pre and post survey that helped us to quantify improvements in team and technical skills. We expect to add additional content related survey questions in later course offerings. Team presentations were evaluated by faculty members on a rubric that emphasized the completeness, relevance, and innovation of the app.

Results:

Apps Developed:

Table 2 below lists the apps developed and their engineering focus. We will provide (in the final paper) references to access all the documentation, code, and presentation material. They are housed at a public GitHub site and are free to download (GitHub, 2016).

Table 2: Health Care Apps Developed

Group No.	Topic	Engineering Sub-Goal
1	Stress Management	Biomarker/ Sensor Interface
2	Healthy Sleep and Sleep Hygiene	Biomarker/ Sensor Interface
3	Caring for Others	Augmented Reality

| 4	Weight Management	Electronic Health Record / IT
5	Healthy Skin	Electronic Health Record / IT
6	Motivational Phrasing for Depressive Symptoms	Augmented Reality
7	Healthy Heart	Biomarker/ Sensor Interface
8	Healthy Brain - Stroke Awareness	Augmented Reality
9	Healthy Cognition and Memory	Augmented Reality
10	Physical Activity	Electronic Health Record / IT
11	Healthy Eating	Biomarker/ Sensor Interface

We have included below a few screenshots of apps to showcase the content relevance achieved.
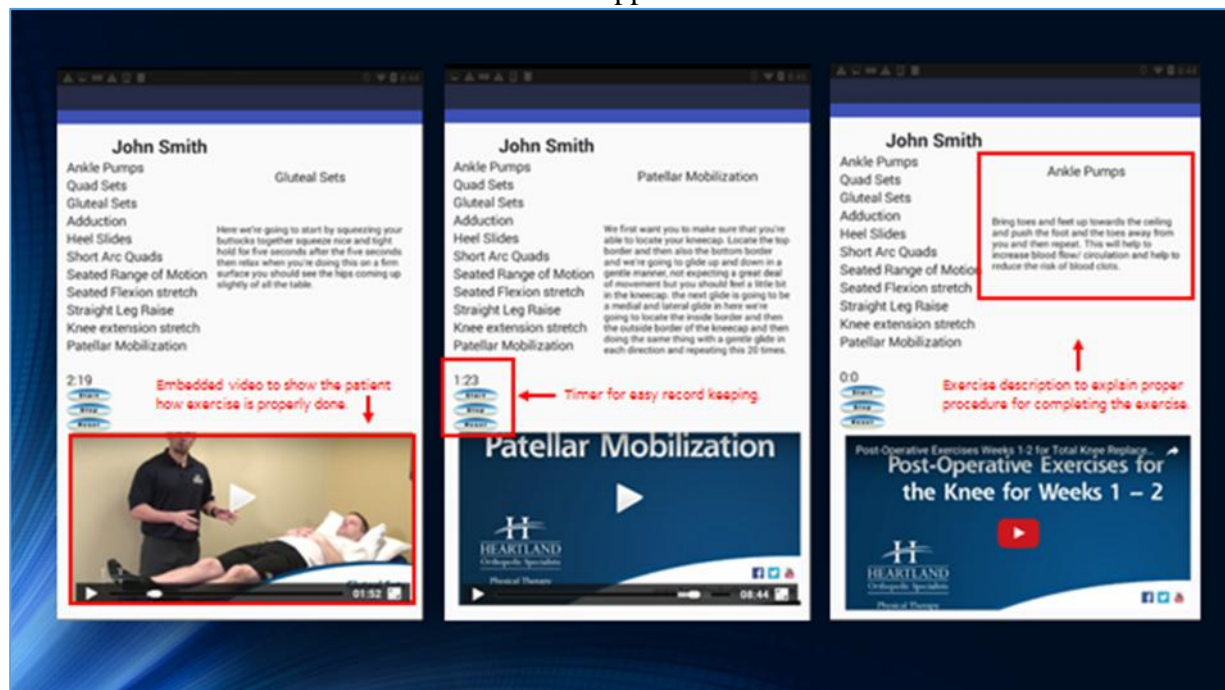

Group 10 on Physician Activity: Physical Therapy exercises for restoring impaired function (three screens shown with different app resources highlighted). Note: Online material, including a third party's videos, was allowed to be included with appropriate acknowledgement.
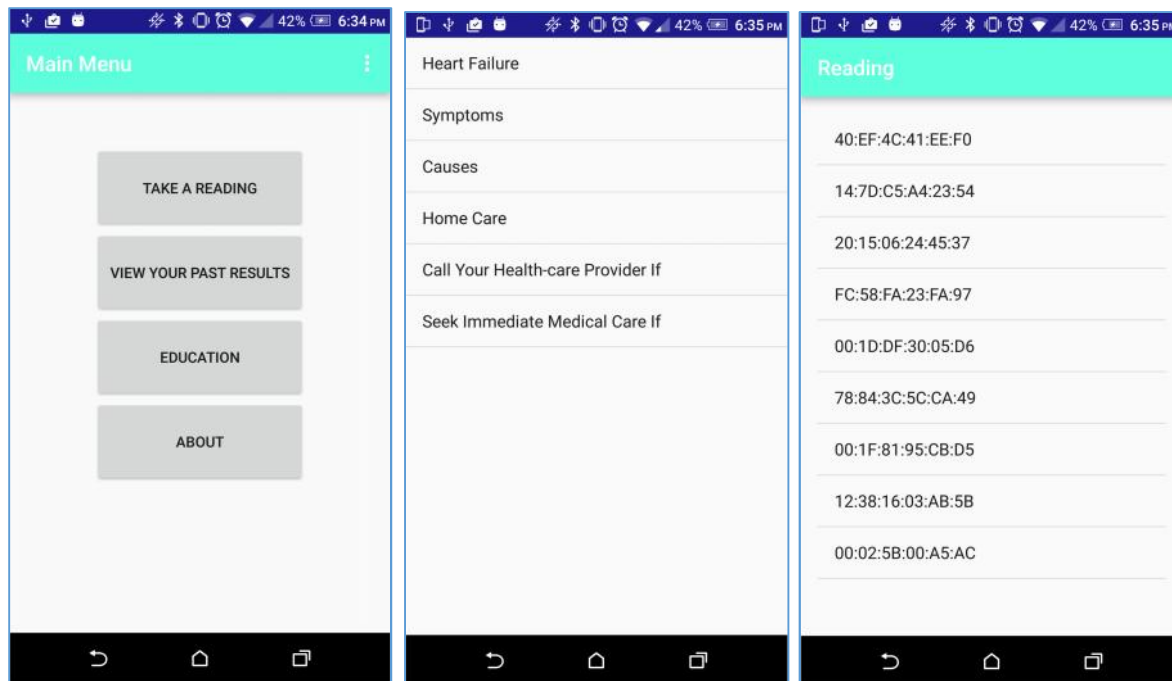
Group 7 on Healthy Heart with Pulse Oximeter interfaced (Three screens shown: Main Menu, Education Tab, and Bluetooth Device list). Data was saved on the local phone to create alerts.
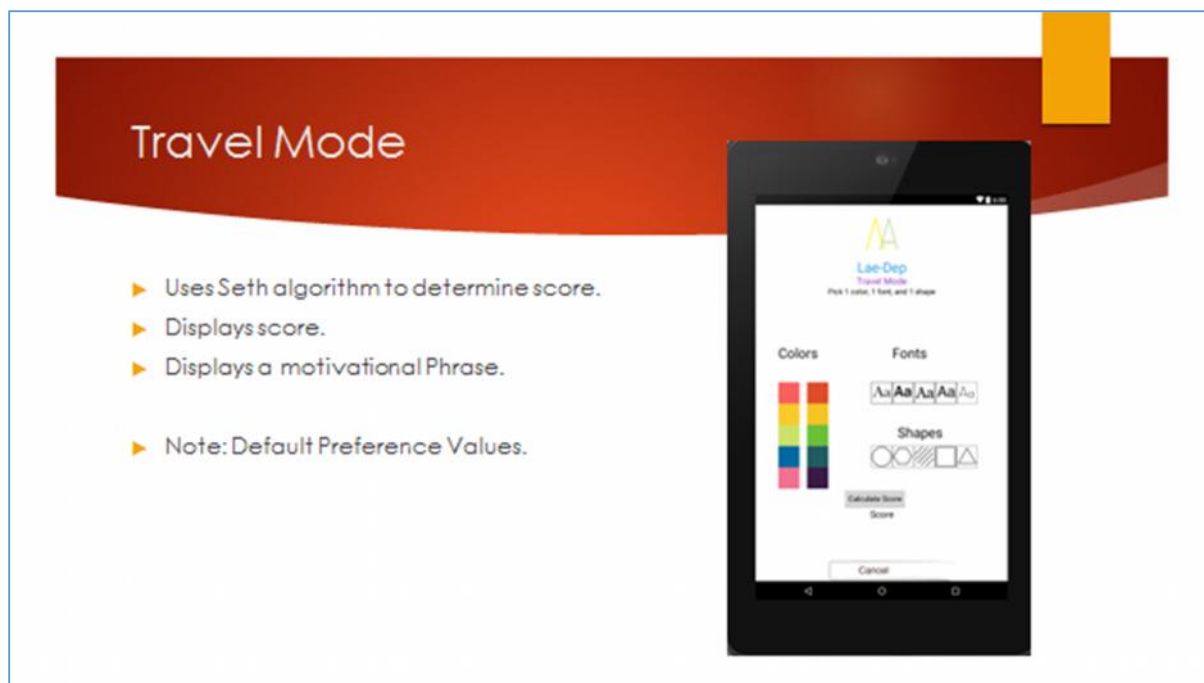
Group 6 on Motivational Phrasing for depressive symptoms, based on an algorithm for tracking user's mood. It provides AR (Augmented Reality) and varying color scheme to improve mood.
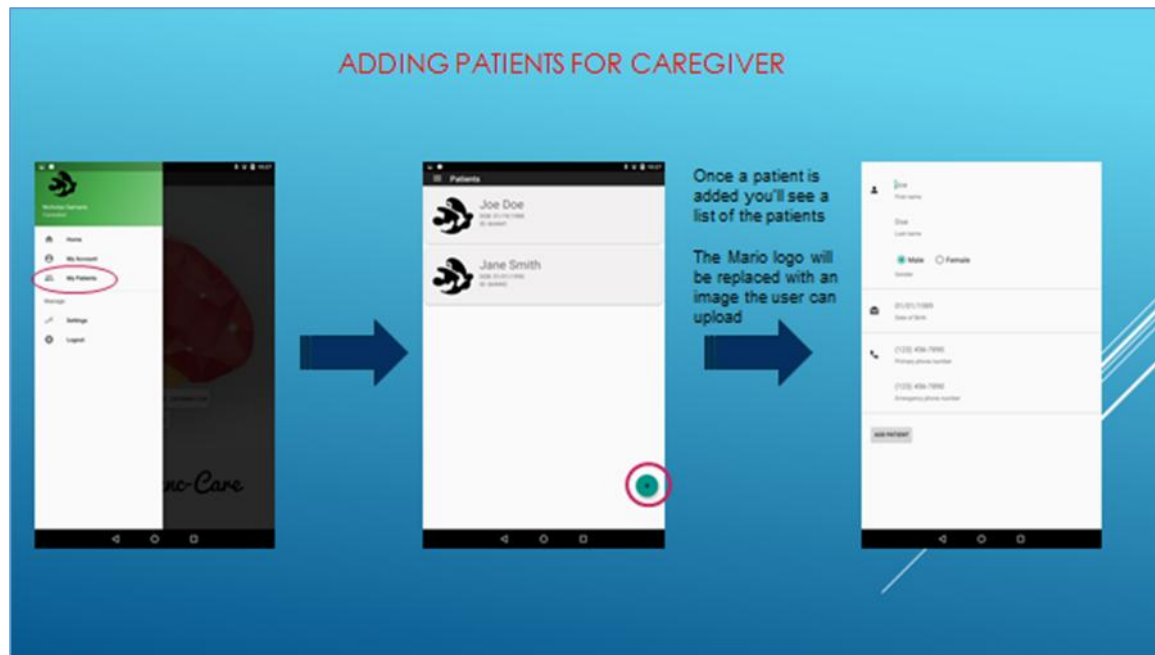
Group 3 on Caring for Others: Three screens show how a new patient is added to a caregiver's list

Survey Results:

We present pre and post-survey results for the first offering of the course. The surveys were conducted as per a protocol approved by our institutional Review Board (IRB) for the Protection of Human Subjects. The protocol is current and is entitled "Assessment for Learning Outcomes for Cross-College Instruction and Student Retention/Graduation." The surveys included 17 questions with focus on multiple learning outcomes. Knowledge gains were assessed on a Likert scale from 1 to 5 where 5 indicated the highest level of self-reported improvement.

The survey questions were focused on three aspects:

(1) App Development Skills: "How much do you know about the following App Elements?" - the app elements included were image capture, video capture, games, mobile web app development, GPS and mapping, text entry, uniqueness, graphics quality, audio effects, and educational use.

(2) Problem Solving Skills: 1."I know how to identify and define a problem when developing the app content." 2.   "I know how to identify and define a solution when I have a technical problem when developing the app." 3. "I know how to create appealing graphics for my app." 4. "I know how to make sure that my app addresses a real world problem." and 5. "I know how to work in collaboration with my teammates to solve a problem."

(3) Communication Skills - 1. "I know who the users of my app will be." and 2. "I have taken steps to make my app user-friendly."

Results are shown in Table 3 given below. Note: we did not cover three app elements (Video Capture, Games, and GPS and mapping, the bolded items in Table 3) in our class material. They were embedded in the survey to act as references to ensure the validity of the instrument and the process.   As noted in the table below, their values did not change from pre to post survey. We used the Mann Whitney Test (for unpaired data), also known as Wilcoxon rank sum test, which is a nonparametric alternative to the two-sample t-test. It is based solely on the order in which the observations from the two samples fall. The test looks at the median rank, so it does not do one-to-one comparisons. That is, the number of observations in the pre and post surveys can be different. For this statistical testing, we used an online tool (Astatsa, n.d.). Null hypothesis is assumed to be rejected if the p value is < 0.10, recorded below as Significant (S); otherwise, it is not significant (NS) that is it is not certain there was a significant difference between the pre and post-survey responses for that category.

Table 3: Results from Pre and Post Surveys

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Survey Question	Pre-Survey (n = 34)	Post-Survey (n = 42)	p value and Significance
Image Capture	1.94 ± 1.91	2.63 ± 1.81	0.289, NS
Video Capture	1.79 ± 1.89	2.26 ± 1.89	0.574, NS
Games	1.94 ± 1.95	1.71 ± 1.81	0.345, NS
Mobile Web App	1.97 ± 1.71	2.62 ± 1.83	0.314, NS
GPS and Mapping	1.68 ± 1.72	1.62 ± 1.95	0.460, NS
Text Entry	2.76 ± 1.78	3.86 ± 1.44	0.010, S
Uniqueness	2.29 ± 1.95	3.39 ± 1.55	0.068, S
Graphics Quality	2.56 ± 1.69	3.52 ± 1.55	0.040, S
Audio Effects	1.74 ± 1.76	2.88 ± 1.89	0.027, S
Educational Use	2.22 ± 1.83	3.48 ± 1.42	0.011, S
Id & define problem	3.15 ± 1.05	3.76 ± 1.34	0.015, S
Id & define solution	2.76 ± 1.39	3.71 ± 1.44	0.004, S
Appealing Graphics	2.50 ± 1.62	3.29 ± 1.62	0.205, NS
Real World Problem	3.35 ± 1.37	3.79 ± 1.35	0.219, NS
Collaboration	4.18 ± 0.83	4.38 ± 0.96	0.288, NS
Targeted Users	3.78 ± 0.97	4.36 ± 0.85	0.027, S
User Friendliness	3.63 ± 1.31	4.24 ± 0.93	0.089, S

Discussion:

From the results above, it appears that we achieved some objectives and not others. The more advanced technology and soft skills were not deemed to have been improved. We believe that it is because of the mash-up of app development environments used (Python/Sketch for biosensor interfacing, Java for Android app development, Mumps for VistA cloud system, etc.). Based on this reasoning and student feedback (through teaching evaluations), we have now moved to platform independent app development (Lingras 2016, and FAU Mobile Apps 2017) using a popular and easy-to-learn language (JavaScript) that can be used throughout the technology ecosystem (from small microcontroller boards to the smart phone to the cloud). The same app will run equally well on both Samsung phones and iPhones. We expect to overcome much of the reluctance and frustration in transdisciplinary collaborations targeted to health care apps.

Future Research: Our next course offering, in spring '18, will recruit juniors in CS and CE, and involve them in transdisciplinary collaborations with nursing and arts students for building healthcare apps. Since this will be an elective course, we will be able to set up a case-control study, with the case group consisting of engineering juniors taking this course. We will track them over the next two years till they graduate on the following fronts: persistence (or retention), and focus of their capstone design project. We hypothesize that retention rate of women and URM students will improve, and that more students will choose social/healthcare projects for their capstone design projects. Another paper submitted to this conference (Shankar et al., 2017b) documents our work on another approach that is under development, based on what-if executable case studies, to improve the retention rates of women and URM students, while helping current mainstream engineering students find new opportunities to apply their technical skills, in the socio-technical context. Research details provided there (Shankar et al., 2017b) are pertinent to this study also.

Conclusion:

Healthcare is undergoing rapid change with significant investment from the federal government, technology companies, and the healthcare industry to improve health care and reduce health care cost. We document here our efforts to bridge the gap so engineering, arts, and healthcare professionals can collaborate to pool their skills and address a health care concern.
Eleven groups, comprised of students from electrical and computer engineering, computer science, nursing, and multi-media, worked together to develop android smart phone apps focused on healthcare. Survey results showed that all participants gained in many technology and team skills. We are currently building a better integrated app development environment for healthcare apps. We also plan to institute additional mechanisms to assess longitudinal formative development of our engineering and non-engineering students.

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