Introducing EngOTG: A Framework for an Audio Study Material App for Engineering Students

Dr. Ghada M. Gad, California State Polytechnic University, Pomona

Dr. Ghada Gad is an Assistant Professor in Construction Engineering at Cal Poly Pomona. She received her PhD in Civil Engineering (Construction emphasis), from Iowa State University. Her main areas of research is in construction management focusing on contracts, procurement, project delivery methods, estimating, and risk management, in addition to the cultural aspects of construction projects. She is also an ExCEED fellow; her teaching pedagogy focuses on adopting active learning techniques in her classes, to increase student attainment and motivation beyond the classroom.

Giuseppe Lomiento, California State Polytechnic University, Pomona

Giuseppe Lomiento is Assistant Professor in the Civil Engineering Department at Cal Poly Pomona. He holds a Master Degree and PhD in Structural Engineering from the Sapienza University of Rome. Prior to joining Cal Poly, he was Project Scientist in the Structural Engineering Department at UC San Diego. His research focuses on earthquake engineering, structural monitoring, and multi-physics analysis. As a Professional Engineer, he has been involved in the analysis, design, and testing of a number of civil engineering structures, including bridges, hospital facilities,recreational facilities, and shipping piers. He is member of the American Concrete Institue (ACI), the Structural Engineers Association of Southern California (SEAOSC), and the International Society for Structural Health Monitoring of Intelligent Infrastructure (ISHMII).

Yu Sun, California State Polytechnic University, Pomona

Dr. Yu Sun is an Assistant Professor of Computer Science at Cal Poly Pomona. He has expertise in the areas of cloud computing, mobile computing, Internet-Of-Things (IoT) and large-scale distributed systems. Before joining Cal Poly Pomona, he was a post-doc research associate at Vanderbilt University, conducting the research on applying Bluetooth sensors to build large-scale indoor navigation system, which has been transferred into a startup company - Ziiio. He has extensive software industry experiences on building large-scale mobile, cloud, embedded and IoT systems. He worked as the Director of Engineering at Cloudpoint Labs, where he led the research and development on the infrastructure of the high-precision 3D augmented reality technology for mobile platforms; He also worked in Amazon Web Services as a software engineer and participated in the development of the world's first cloud-based mobile web browser for Amazon Kindle Fire tablet. Recently, he founded SoftCom Lab in Computer Science Department to organize students on research and startup projects.

Introducing *EngOTG*: A Framework for an Audio Study Material App for Engineering Students

ABSTRACT

Auditory learning tools, such as recorded study materials, are very commonly used in many disciplines and have proven to be effective for second-language learners, learning-disabled students, and struggling readers. However, such tools have been seldom used in science, technology, engineering, and mathematics (STEM) education, mostly because of the technical nature of the subjects. The objective of this study is to investigate the features of audio study materials that could improve student learning and attainment of basic engineering concepts that are generally known by students to be difficult and require substantial processing and repetitions. This study presents a literature review on the subject, encompassing learning and lifestyles of millennial/Gen Z students, and available technology tools, and the development of a framework for a mobile learning audio app. The framework leverages motivational and portability characteristics to make the learning materials accessible to students engaging in common daily activities such as commuting and exercising. Based on the framework, a beta version of the app, called Engineering On The Go (EngOTG), has been deployed to enhance learning in the Mechanics of Materials course, a course widely recognized as one that engineering students have learning difficulties with.

INTRODUCTION & BACKGROUND

The availability of new technology is shaping the daily habits of the newer generation and is strongly influencing their learning styles. These generations constitute the 'millennials' referring to these born between 1980 and 1994, and the 'Generation Z (Gen Z)' born between 1995 and 2015. Reaching this generation requires that educators not only understand the difference between this new audience and the older ones, but also collaborate with this audience to incorporate a variety of instructional delivery methods, to engage the students in a way that is more consonant with their learning and living habits. Learning experiences that provide rewards for participation, provide frequent feedback, and foster an interactive environment through the inclusion of a variety of technology media has proven to be effective with millennials (Monaco & Martin, 2007). It is known that millennials/Gen Z are technologically savvy and are used to having immediate access to a vast amount of information, which is offered in a variety of verbal and nonverbal forms. In addition, there is significant evidence in educational research that students - in general - benefit most from using mixed modality learning styles (visual, auditory, and kinesthetic). The dual-coding theory suggests that nonverbal objects or events, such as images, and verbal language and audio have an additive effect on learning and memory (Paivio, 1986). A combination of those is hence ideal, even if some content is recognized to be better suited for images while other contents can be more effectively conveyed through audio presentation.

Auditory learning styles, such as recorded study materials are very commonly used in many disciplines and have proven to be effective for second-language learners, learning-disabled students, and struggling readers or nonreaders. It is not surprising to see audio modes seldom used in science, technology, engineering, and mathematics (STEM) education, as STEM fields are proven to be more hands-on, requiring problem solving and experimentation for enhanced understanding. However, auditory learning modes offer advantages not available in other learning modes, such as visual and kinesthetic, the major one of which is the convenience of learning anywhere (*on the go*) without requiring the cognitive load associated with image processing. Learners can benefit from audio material while still performing physical tasks at the same time, such as commute or exercise. Audio learning materials can also be made more easily available and incorporated into students' daily activities if they are accessible on a mobile phone through a software application (app). This also allows repetition and practice on the go.

A project has been initiated in order to leverage these features and provide students with a highly accessible and portable audio app for engineering education. The project comprises two phases. The first phase consists of a comprehensive literature review on the subject and the development of the framework for the audio app. A second phase is then used for the assessment of the effectiveness of the proposed tool. ***This study focuses on the first phase of the project, and thus aims at (1) conducting a thorough literature review on the use and the benefits of audio learning materials that address the engineering subjects, and (2) developing an audio learning framework for engineering students that encompasses repetition, feedback, and accessibility to improve student learning and attainment of basic engineering concepts, that are generally known by students to be difficult and require substantial processing.*** Given the nature of the subject selected being Mechanics of Materials, one of the main challenges of the project is to provide students with audio contents that address mathematical concepts by means of appropriate language, timing, and examples in order to facilitate understanding and learning. The paper will start by introducing the methodology employed, followed by a thorough literature review setting the stage for the framework development, and finally followed by conclusions and recommendations for future steps.

METHODOLOGY

To achieve the objectives of the paper, the methodology is divided into two main steps. The first step includes a thorough literature review of the existing literature. The topic of this study being 'audio learning' is in overlap with three main major topics in the field of education, which are learning styles, millennial/Gen Z lifestyle, and the use of technology in education as shown in Figure 1. Thus, these three major areas were thoroughly investigated in literature to cover the current state of the art in these areas and build on it. Using the literature review as the benchmark, the second step included the development of the audio study app framework. The framework was based on identifying from the literature the need for the app, the technology aspect of developing the app, the characteristics of the audio recordings, and the constraints imposed by the millennials/Gen Z life and learning styles, and by the nature of the subject.

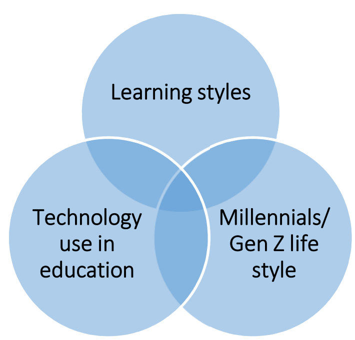

Figure 1: Literature Review Topics Overlap

LITERATURE REVIEW

In order to be best able to benchmark the state of the art, and accordingly the need for an audio learning tool to improve student learning and attainment of basic engineering concepts, it is necessary to address the major underlying principles that form the basis of this topic, including (1) learning styles, (2) millennial/Gen Z lifestyles and learning styles, and (2) technology use in education.

1. Learning styles

Learning styles is a well-researched topic in the field of education. It is well-established that students have different preferred learning styles that directly impact the assimilation and retention of course content, and thus overall student achievement. There are many benefits for either a student or an instructor to understand learning styles, as instructors can develop teaching strategies to cover differents mode of input, while students could be more effective learners by adjusting their study habits and the way they take notes to accommodate their modality preferences. These facts lead to challenging implications on the instructors in terms of awareness of the students' preferred learning styles, accommodation of such learning styles through different teaching approaches, and finally the assessment of the student learning (Driscoll & Garcia, 2000).

In order to better assess and accordingly accommodate student learning styles, researchers categorized students' learning styles in different ways usually on a bipolar continuum following the underlying fundamentals of learning: (1) processing of information: perception (sensing/intuitive), (2) input modality (visual/verbal), (3) organization (induction/deduction), (4) processing (sequential/global), and (5) understanding (active/reflective) (Driscoll & Garcia, 2000). Many assessment tools/surveys were developed to determine students' learning styles that vary in their complexity, ease of administration, quality of information, etc. Examples of these include the VARK catalyst which divides input modes into four areas: visual (V), aural (A), read/write (R), and kinesthetic (K). Visual learners are these that prefer pictures and diagrams; aural learners are the ones who prefer spoken words; read/write learners prefer the words being written down; and finally, kinesthetic learners can accommodate other modes but prefer real hands-on experiences such as demonstrations and real-life examples (Driscoll & Garcia, 2000). The Index of Learning Styles (ILS) is another popular instrument used to assess students' styles based on four dimensions of Felder-Silverman learning style model. These include sensing/intuitive, visual/verbal, active/reflective, and sequential/global (Felder & Spurlin, 2005).

These tools has been used by researchers to assess engineering students' specific learning styles. For example, Driscoll and Garcia (2000) used the VARK catalyst (Visual/Aural/Read-Write/Kinesthetic) to investigate Chemical Engineering students learning styles. Results of their study showed that student learning styles differed from what their instructors believe, and that these styles are firmly in place by the time a student reaches the university. The preferred learning style for most students was the kinesthetic (hands-on) mode, either by itself or in combination with other learning styles (multimodal). There were no pure visual learners, and visual input was a preferred mode of input for only 27% (3/11) of the multimodal learners. The high aural preference as part of the multimodal distribution 64% (7/11) was also significant for this study (Driscoll & Garcia, 2000). ILS was heavily used to assess engineering students learning styles by various other researchers, with these results being used to test its reliability and validity. Results compiled from 10 engineering schools, showed engineering students to be more active than reflective, more sensing than intuitive, more visual than verbal, and more sequential then global (Felder & Spurlin, 2005). Moreover, Zywno (2003) found that students performed better in classes taught in their favorable learning styles, and that the introduction of different modalities, such as media reduced the performance disparity among students (Zywno, 2003).

2. Millennials/Gen Z life and learning styles

To add to the complexity of learning styles, the millennial and Z generations comes with their evolving lifestyle and habit, which varies from being digital natives to commuters to campus and affect the students' study habits. Understanding these habits can help instructors better design learning tools that can be both effective and convenient for the students' lifestyle. The next sections focus on two prominent features of today's student lifestyle; a commuter and a digital native.

A Commuter. The commute aspect of student life is not to be defined in terms of its overall effect on the student academic experience. Universities specifically located in larger urban cities observe a considerable percentage of commuter students that spend considerable time commuting back and forth to campus. This is mostly attributed to the affordability aspect of commuting rather than living on campus. At the University of Southern California for example, due to the high housing prices, students live in their parents' homes or less expensive areas, resulting in a high commute time (Lochead, 2017). Lochead (2017) article quotes a student "*The journey home is annoying and exhausting. I have to do any schoolwork at school before or after class. I spend an average of 20 hours a week commuting. That is time I could be improving my academics, or going to the gym."*

Commuting is argued to have a negative effect on the student overall learning experience whether on the social aspect or academic performance. The average off-campus travel for students in the U.S. is around 22 miles (Grove, 2013). A study conducted by Lumina foundation (2011) to address the decrease in graduation rates, shows that only 25% of college students attend full time and live on-campus, while the rest commute to school while juggling back and forth to work and home (Lumina Foundation , 2011). This data, which is based on 33 participating states, is eye-opening showing how our education policies and consequently teaching strategies are geared towards the traditional full-time student, who lives on campus, while the fact is the majority of our students are truly nontraditional (Lumina Foundation , 2011). The report concludes with several action items to educational institutions, one of which is to *"Restructure programs to fit busy lives."*

Another study conducted by The Ohio State University in 2015 revealed that students living on campus tend to be way more involved in student organizations compared to commuter students (63% versus 33%) (Center for the Study of Student Life , March 2015 ; Kuh, Gonyea, & Palmer, 2001). This reflects in less opportunities for skill development for commuter students, as well as the imperative nature of commuting taking time from studying (Lochead, 2017). Another study by Kuh et al. (2001) also show that commuters have less level of interaction with faculty. All these negative effects of commuting may finally lend themselves to students who are less committed to completing their education, a concern clearly made by Lumina's foundation study and proven by other studies (Bozic, 2008).

An additional dimension highlighted by Bozic (2008) about commuters is the aspect of commuters being economically disadvantaged compared to their peers. This is because students that come from low-income families were seen to work, as well as live at home during their freshman year. The problem is that such "cost-saving strategies" end up impeding their chance of completing college because of their reduced engagement to campus life, and most importantly to the educational process at large. The academic performance of commuter students compared to their non-commuter peers was indeed studied by Nelson et al (2016) on a sample of students in East-Central Michigan University. The study investigated the relationship between a student's commute length and the student's success, which was measured by their overall grade point average (GPA). Initial results of this study found a negative relationship between commute distance and GPA that posed the need for further investigation of other factors that might have affected the GPA.

These studies shed the light on an important aspect of students' lives that should be further addressed by educational institutions to account for this population of students when planning policies and intervention plans. These might include for example "*the development of more online course opportunities [that] may help these students succeed*", as well as offer them more convenience. In essence, the commuting aspect of students' lives introduces the main theme that if being a commuter means fewer opportunities for skill development, then providing support online would be a possible option for giving those commuters more access to skill building activities (Nelson, Misra, Sype, & Mackie, 2016), and enforcing the idea that the traditional singular mode of learning followed by universities may not be the best suited to the pace and rhythms of life for commuter students.

*A Digital Native***.** The other prominent aspect of students' life, which is more specifically related to millennials and Gen Z, is their extensive use of technology. They are identified as Digital Natives, as they "grew up with access to computers and the Internet and is therefore inherently technology-savvy" (Margaryana, Littlejohna, & Vojt, 2011). In fact, this immense exposure to technology is argued to have made them develop new learning styles.

A study was conducted by Magaryan et. al (2011) to gain a better understanding of the patterns and contexts of adoption of technology by college students. It showed that 'Digital native' students of technical disciplines, such as Engineering use more technology tools, in comparison to 'digital immigrants' and students of a non-technical disciplines, such as Social Work. However, students did not seem to transfer their technology savviness to the academic context automatically; it was more based on what the instructor introduce the students to (Margaryana, Littlejohna, & Vojt, 2011; Kuman, 2010). Kuman (2010) also investigated how undergraduates use technology for both academic and personal purposes, and revealed a huge gap between the students' use of technology in these two different settings, with students mostly using technology in a personal informal rather than academic settings. Students, however, appreciated the use of technology (such as Wikis and Google), to enhance their learning experience in different settings. Students were seen to be consumers rather than producers of these technology tools. Thus, in an educational setting, their use of technology would be dependent on their instructor's implementation of technology tools in class.

3. Technology use in education

With the millennials/Gen Z being digital natives, it is not surprising that the 2012 University Horizon Report (Johnson, Adams, & Cummins, 2012) suggested that students are expecting changes in the way learning contents are delivered, presented, and made accessible. The main findings are that students want to learn anytime, anywhere, possibly by accessing content on the cloud. They also want digital media to be interactive, socially based, fully integrated, and inexpensive (Johnson, Adams, & Cummins, 2012).

E-textbooks is one of the ways learning content can be made more widely accessible. These are texts that are digital and accessed through computer screens or mobile devices. In Szapkiw et al. (2013), a survey demonstrated that 61% of the users' respondents choose e-textbooks over traditional textbooks mostly for the lower price, while only a few appreciated the portability of the tool (16%). The results of this study also indicated that students who used e-textbooks for their education courses "*had significantly higher perceived psychomotor and effective learning than students who choose to use traditional print textbooks. That is students who used e-textbooks perceived better acquisition of skill*". Moreover, the use of e-textbook provided "*an increasing internalization of positive attitudes toward the content or subject matter*" as compared to the print textbook. However, only 51.9% of the surveyed students said that they would adopt an e-textbook in the future. Students still overwhelmingly prefer traditional textbooks mostly due to familiarity with print versions and the simplicity of highlighting text, dog-earing pages, and taking notes (Szapkiw, Courduff, Carter, & Bennett, 2013).

Wider use of new learning technologies though can be reached by (1) incorporating motivational features and (2) improving portability of the learning tool. Several studies address the effect of the motivational aspect that new technology can add to the learning experience. An example of motivational feature is provided in Grosse and Renkl (2007), where the inclusion of intentional incorrect statements in teaching modules and blogs is used to make learning contexts challenging. The study reports an increased students' motivation to learn, which results in a deeper engagement in the class materials, and ultimately a deeper learning experience (Grosse & Renkl, 2007). Also, the inclusion of positive emotional design in educational multimedia is effective in increasing the learner's performance. The positive effects of emotional graphical design on comprehension tests and self-ratings of motivation were also studied and highlighted (Plass, Heidig, Hayward, Homer, & Um, 2014). Mayer et al. (2014) presented the difficult balance between course contents and the motivational features, and noted that not all forms of motivational aids are actually effective in promoting learning. The motivational features implemented in multimedia tools have a positive effect in engaging learners and fostering deeper processing if they are not overwhelming or distracting from the core material (Mayer, 2014).

Portability is the second crucial feature that differentiates and gives value to multimedia tools compared to the traditional learning environments. A way of making technology more portable and accessible to students "*on the go*" is the use of mobile technology for learning, also commonly referred to as 'mLearning'. This technology is still in its infancy since mobile devices are going through constant improvement of their communication and processing capabilities. This creates a challenge for the development of mobile learning tools since contents need to be continuously adapted to ensure efficient use of mobile resources. Promoting mobile learning requires that the learning resources must be available and functional on a variety of mobile devices, ranging from low-tech ordinary devices to high-tech smartphone devices (Quinn, 2000). Device-independent delivery of learning content and management is one of the preferable features of mobile learning tools. In order to incorporate this feature, recent mobile apps are optimized to overcome most of the issues associated with differences in mobile devices, and they can be easily downloaded and used by students.

Apps are already used in several fields to improve the students' learning experience. Web-based learning is becoming common, and social media apps are considered among the most effective ways to attract students towards this technology. Web-based learning, however, is not always preferably pursued over portable mobile devices, but rather on tablets and laptops. A recent survey on Japanese language students using web-based learning tools such as Facebook apps showed that when it comes to using of mobile and computer apps for learning, the most common reason behind preferring a computer over a mobile device is that text and photos are easier to see on a computer screen (31% of comments) (Tabuchi, 2011). The second main reason is that the navigation and the typing of texts is more difficult on a mobile phone than on a computer. Limiting the need for visual aid and text input is crucial to make mobile learning apps more appealing and easily accessible to students. The most stated reason for why a mobile app is preferred over a computer app is already the convenience of the "anytime/anywhere" use (25% comments). Improving portability is, hence widely recognized as the most important feature of learning mobile apps. Similar studies were conducted on Australian and German students. Khaddae and Latenman (2013) confirmed the strong interest of students in mobile technology for distance learning. An astonishing 85% and 70% of all the surveyed Australian and German students, respectively, perceived mobile apps as useful for remote learning, with the most commonly used apps being language programs and apps for quizzes and tests (Khaddage & Lattenman, 2013).

Podcasting apps come as an effective way of making the technology available on a variety of mobile devices and further promoting portability due to the limited use of visuals and text inputting. Cebeci & Tekdal (2006) defined podcasting as "*a new innovative method of Web-based broadcasting that may be used for automatically transferring digital audio content to mobile devices*." The clearest advantage of podcasting over any other mobile learning technology is the extreme portability, which allows listening to learning resources anytime and anywhere. Audio apps rely on simple technology and podcasts can be downloaded to almost all kinds of mobile devices. Other advantages of audio apps that are recognized for mobile learning are that listening may motivate students who do not like reading and that they may be a useful tool in e-learning environments for the visually challenged. Also, when audio is used in mobile learning, in addition to audio output, designers can use audio as an input mechanism. The application of speech recognition can use automated or human interfaces and is an important feature of mobile learning design that can drastically reduce the need for manual inputs, and as such, warrants further study. The learner can use this feature for inputting content or applying commands, thus reducing the difficulty of using miniature keyboards (Cebeci & Tekdal, 2006). The main benefit of Automated Speech Recognition (ASR) was identified by Koester (2004) as being the reduced fatigue associated with manual input methods. A secondary benefit of ASR is the increased inputting speed and control of the app. An additional evident benefit of such feature is the adaptability to situations which involve the use of hands, such as driving for commuting students or exercising for students involved in physical activities (Koester, 2004).

Currently, most learning podcasts available over the Web are just audio files recorded and not specifically distributed for educational purposes. These podcasts may become valuable learning objects with a clear educational value if they are integrated with features such as:

1. inclusion in Learning Object Repositories (LOR) for easily reusable, accessible, and searchable audio learning objects,
2. inclusion in Learning Content Management Systems (LCMS), i.e. systems that allow assembling learning objects for various purposes, thus achieving personalization and meeting the individual learning style of each learner,
3. consideration of psychological limits of learners, the main ones being the difficulty of keeping attention in listening for long objects with a subsequent decrease in comprehension, and the strong impact of the topical depth or complexity of the subject on the learners' attention, and
4. pursuing high-quality audio learning material, achieved through qualified sound processing techniques.

The flexibility of merely listening rather than having a complex multimedia experience is a technological advantage of podcasting as it may make mobile learning apps more portable, applicable, and cheaper in comparison to counterparts, such as Web-based mobile learning. Audio apps can be conveniently designed to meet the four main design principles identified by Wang et al. (2012) for effective mobile learning:

1. design for the least common denominator, meaning that the app may be available for download and use on low-tech to high-tech mobile devices. Compared with smartphones, the functions of simple mobile phones are limited and might require that learning content is packed into smaller chunks
2. design for eLearning, adapt for mLearning: among all the mobile devices, an audio app can be an excellent tool for mobile learning. It can provide a pleasant learning environment and resolve several of the possible issues associated with small screens
3. design short and "condensed" materials for smart phones: the smartphone's size is a key limitation for some users, such as older learners with diminished eyesight and dexterity. The audio app with voice recognition can solve issues associated with the difficulty of interacting with a smart phone's small keyboard and screen
4. be creative when designing for mobile devices: leverage new wireless technologies that offer a different way for users to connect with the public, the higher capacity of data transmissibility, and the most modern software architecture (Wang & Shen, 2012).

With a new generation of 'digital native' students who grew up with technology, it is anticipated that the use of an audio study app that is accessible on their phones, would align with their lifestyle. It will provide them with a learning resource which is accessible anywhere, and would ultimately improve their understanding of difficult concepts, as well as allow for practice and repetition at their own convenience.

FRAMEWORK DEVELOPMENT

The proposed mobile learning tool consists of an audio study app for engineering courses, named Engineering *On The Go (*Eng*OTG).* The audible app would allow students to (1) select a concept they want to learn, (2) listen to the explanation of the concept, and then (3) test their knowledge of the understanding of the concept using multiple choice questions. The project will start by targeting the Mechanics of Materials course, which has been recognized as one of the 1,294 bottleneck courses throughout CSU's 23-campus system during the 2012-2013 academic year. It is widely known that students have difficulties in learning concepts and skills associated with typical basic mechanics problems. Typical problems encountered by students include difficulties in distinguishing between internal and external forces, an inadequate distinction between forces and moments, and difficult translation of internal forces into internal stresses (Steif and Hansen 2006).

Using this app, the student is asked to select from a multiplicity of available concepts, for example, a concept option could be 'internal and external forces' or 'forces and moments'. After the student has selected the topic, the student is prompted to listen to at least two different short audios covering the topic. The two different audios – for the same concept- are intended to cover the topic in two different ways, which could be by simply providing different elaborative examples, or by addressing the concept from an entirely different angle. The student can choose to repeat the audio as much as he/she would like and can then move to the 'Test your knowledge' mode. In this mode, the student will be prompted to answer a set of 4-5 multiple-choice questions, using interactive voice response (IVR) systems implemented by the AI-based voice recognition and text-to-speech techniques, giving the student three choices (either 1, 2, or 3). Once the student selects the answer, he/she will be provided feedback whether he/she answered correctly or not. The student could choose to try a second attempt to answer the question, or just reveal the correct answer, and will be given feedback of his/her score, and revision of the concept (if the app is prompted) at the end of this process. The student could choose to restart the entire process again, yet this time with a different set of questions. For the app to function, it is linked to a LOR that incorporates, for each learning concept at least two explanation audios and a test bank of a minimum of 20 questions. The app is developed to allow the user to answer multiple choice questions in an audio-response format (like the one used by the telephone services).

In a second stage, the project will encompass two major assessment methods, a direct and an indirect tool. The direct tool will be through assessing the attainment of the students of the identified topics in the course. This will be achieved through a set of problems that will be included in tests administered to students in the course. The tests will be administered to students in two different classes; one where audio study reviews were provided to the students as a learning study guide, and the other where students were using the traditional studying tools (acting as a benchmark). These tests will be administered to students twice, once mid through the semester, and the second time as part of the final. On another hand, the indirect tool will aim at capturing the students' perceptions and opinions of the audio study reviews. This will be achieved through surveys administered to students twice as well, once mid through the semester and the other in the last week of classes. Mid through the semester, the results of both the direct and indirect tools will be analyzed offering formative assessment to implement suggested improvements to the app and/or the study material to make it more effective for the students. The following two hypotheses will be tested:

1. *Audio reviews increase the student attainment of engineering concepts* - tested by the results of both the midterm and final problems (direct tools), and
2. *Audio reviews provide students an effective method to study in different settings*- tested using the survey (indirect measure).

The proposed project will impact approximately 40 Civil Engineering students during the first year of deployment. Once proved successful based on assessment results, the audible app can be deployed in all the Mechanics of Material classes offered by the Civil Engineering department, affecting approximately 250 students per year and considered for further distribution.

A schematic of the app framework that stemmed from benchmarking the existing literature is presented in Fig. 2. The framework comprises four main activities, which were successfully completed for deployment of a beta version of the app:

1. ***Content selection*** includes identification of the subjects and definition of learning objectives. Subjects recognized in the literature as particularly challenging for students were selected (Steif and Hansen 2006). A limited number (2 to 4) of learning objectives were chosen for every single podcast in order to limit the topical depth of the subject.

Figure 2. Mobile Learning tool development framework

2. ***Screenplay writing techniques*** have been used to present the subjects in an informal and situational context. The subjects are mostly presented as dialogues between students and relate to everyday circumstances in which students may interact. The casual presentation is a motivational feature that could foster attention through humor and real-life scenarios. For example, on the topic of normal and lateral strains, a conversation between two actor students, one of which suffering from a strained muscle, forms the basis of the casual discussion on the topic in an interactive way that students can easily relate to. A narrator's voice is included to introduce the technical subject and to summarize main points. The total audio length is

designed to be between four to six minutes long, to limit the risk of loss of attention. The comprehension assessment tools are presented as multiple-choice quizzes, related to the situation presented in the narrative.

3. ***High-quality audio recording*** is used to improve the learner experience. Student actors were hired to present the narrative in a way that millennial/Gen Z students can relate to.
4. ***The app design*** includes the development of the architecture of the app, as well as the creation of the management system for contents and assessment tools (LCMS), and repositories for each subject (LOR). Voice activated commands are implemented to reduce or in the future totally eliminate manual inputting.
5. The distribution of the audios to ***any basic smart mobile phone*** is carried over the internet, but an intranet option is envisioned to distribution within the university's platform.

The framework to support the idea is based on the trending technologies on mobile computing, cloud computing, and AI techniques on voice recognition and natural language processing. Figure 3 shows an overview of the Audi mobile app. The mobile app supports the following key functionalities: 1) Students can choose the specific topics to learn; 2) The learning is based on audio materials so that students can listen at anytime and anywhere; 3) Quizzes are available for students to test themselves, using the audio input.

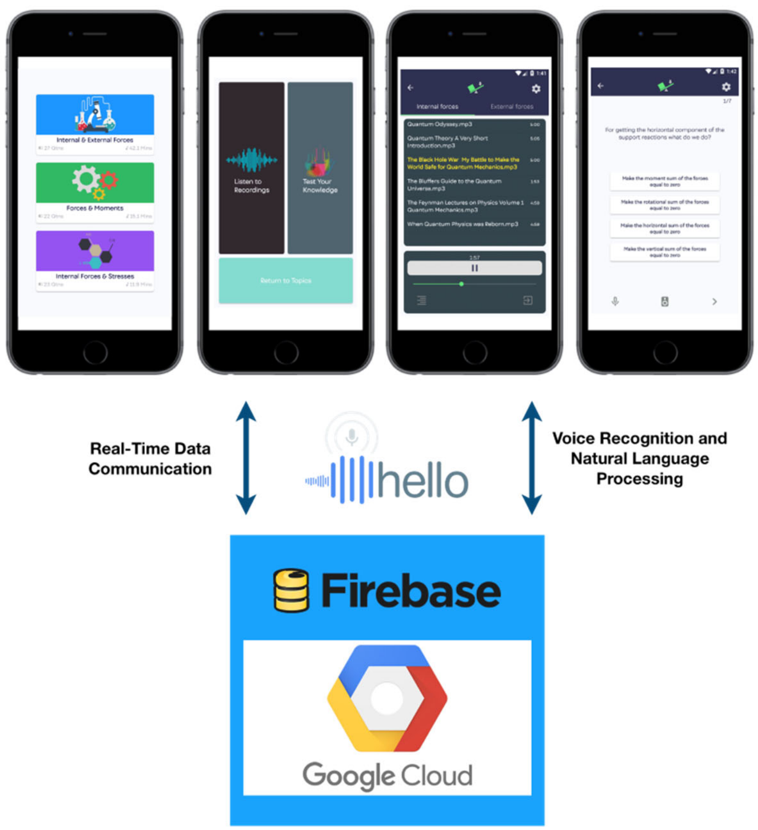

Figure 3. An Overview of the Audio Application Beta Version Architecture

The first beta version of the app has been developed in Android and is already published in Google Play. The app is implemented by leveraging the following technologies:

- **Firebase Cloud Backend.** Firebase is a trending cloud-based database as a service provided by Google. It has a wide range of backend features to support mobile app development. The key feature integrated to our application is Firebase Realtime Database and Firebase Storage. Firebase Realtime Database Store and sync data with our NoSQL cloud database. Data is synced across all clients in real-time and remains available when the app goes offline. This allows the admins to update the content anytime and ensures the promptly delivery of the content. Firebase Storage is used to store the audio files, with great scalability.
- **Voice Recognition.** Voice is the main approach to support user interaction with the app. The Audio app uses Google's Voice Input AI to conduct real-time voice recognition and text to speech features. The recognition works in both online and offline mode, so the app can still function in the conditions when the Internet connection is not available.
- **Natural Language Processing.** Most of the quiz questions are multiple-choice questions, where students only need to answer simple choices such as "A", "B", "C" and "D". This type of answers can be captured and supported easily because it does not have much complicated language context. However, we also plan to support the questions that require brief explanations. The Google's Natural Language Processing API has been integrated into the app, so we can capture the core concepts from users' voice input, and more important enable computers to understand the answer and compare it with the correct answer accurately.

CONCLUSIONS AND RECOMMENDATIONS

Millennial/Gen Z students' lifestyles and habits can be viewed to impose challenges to the traditional learning modes used by instructors. However, it actually provides instructors opportunities to innovate by incorporating a variety of instructional delivery methods, and to develop the existing educational tools to accommodate this new generation of learners' changing needs. One of these continually emerging delivery methods and technologies is the use of mobile applications to engage the students in a way that is more consonant with their learning and living habits. This paper aimed at setting the stage for the implementation of an audio app to enhance and accommodate the students' lifestyle and learning styles. This was achieved by first conducting a thorough literature review on the use and the benefits of audio learning materials, from which the audio learning framework was developed.

The first step which is the literature review revealed the considerable effect that the students' lifestyle (commuter and digital native) and learning style (auditory, visual, kinesthetic) has on their social engagement and/or academic performance in college. A deeper investigation into the technology use in education revealed the high potential of employing audio apps to accommodate both the learning (audio convenience) and the lifestyles (portability for commuters) of the millennial/Gen Z students. This informed our framework development that had to account for a set of constraints, including selecting material that is known to be hard for students to comprehend, encompassing a motivational feature in the learning experience to make it more engaging, adopting the voice recognition technology to make it more convenient, and designing an app that can be being easily installed on any basic smart mobile phone. This paper thus presented a promising educational framework and a tool that meets engineering millennial/Gen Z students learning styles and lifestyles. The app will be further deployed this semester in the Mechanics of Materials class, and assessment of both the students' learning experience and material attainment will be conducted to further refine the framework. If successful, this app will not only have a huge potential in enhancing the students' learning experience, but will also address one of Lumina's report main goals of 'increasing student retention' through 'restructuring programs/instruction modes to fit the students' busy lives'.

BIBLIOGRAPHY

Bozic, R. (2008). *Student Employment during the Transition College in the United States.* RTI Press Publication.

Cebeci, Z., & Tekdal, M. (2006). Using Podcasts as Audio Learning Objects. . *Interdisciplinary .Journal of E-Learning and Learning Objects, 2*(1), 47-57.

Center for the Study of Student Life . (March 2015). *Comparing On-Campus, Off-Campus, and Commuter Students.* Ohio: The Ohio State University.

Driscoll, S. A., & Garcia, C. E. (2000). Preferred Learning Styles for Engineering Students. *ASEE Annual Conference.* St. Louis, MO, USA. Retrieved from https://peer.asee.org/8639

Felder, S., & Spurlin, J. (2005). Applicaitions, Relaibility, Validity of the Index o Learing Styles. *INternational Journal of ENgineering Education, 21*(1), 103-112.

Grosse, C. S., & Renkl, A. (2007). Finding and fixing errors in worked examples: can this foster learning outcomes? . *Learning and Instruction, 17*, 612-634.

Grove, J. (2013, July 13). *Students spending millions commuting*. Retrieved from https://www.timeshighereducation.com/news/students-spending-millions-commuting/2005786.article

Johnson, L., Adams, S., & Cummins, M. (2012). *The NMC horizon report: 2012 higher education edition.* . Austin, Texas: The New Media Consortium.

Khaddage, F., & Lattenman, C. (2013). The future of mobile apps for teaching and learning. . In Z. L. Berge, & L. Y. Muilenburg, *Handbook of mobile learning* (pp. 119-128). New York: Routledge.

Koester, H. H. (2004). Usage, performance and satisfaction outcomes for experienced users of speech recognition. *Journal of Rehabilitation Research & Development, 41*(5), 739-754.

Kuh, D., Gonyea, M., & Palmer, M. (2001). The Disengaged Commuter Student: Fact or Fiction? *Commuter Perspectives*.

Kuman, S. (2010). The Net Generation's Informal and Educational Use of New Technologies. *In education: exploring our connective educational landscape, 16*(1).

Lochead, P. (2017, December 9). *Life of a commuter: The long road to school*. Retrieved from http://www.uscannenbergmedia.com/2017/12/09/life-of-a-commuter-the-long-road-to-school/

Lumina Foundation . (2011). *Time is the enemy.* Complete College America.

Margaryana, A., Littlejohna, A., & Vojt, G. (2011, February). Are digital natives a myth or reality? University students' use of digital technologies. *Computers & Education, 56*(2), 429-440.

Mayer, (. E. (2014). Incorporating motivation into multimedia learning. *Learning and Instruction,, 29*, 171-173. doi:ISSN 0959-4752),

Monaco, M., & Martin, M. (2007, April-December). The Millennial Student: A New Generation of Learners. *Athletic Training Education Journal, 2*(2), 42-46.

Moreno, R. (2005). Instructional technology: promise and pitfalls. (M. B. L. Pytlik Zillig, Ed.) *Technology-based education: Bringing researchers and practitioners together*, 1–19.

Nelson, D., Misra, K., Sype, G. E., & Mackie, W. (2016). An Analysis of The Relationship Between Distance From CampusAnd GPA Of Commuter Students. *Journal of International Education Research, 12*(1).

Paivio, A. (1986). *Mental representations.* New York: Oxford University Press.

Plass, J. L., Heidig, S., Hayward, E. O., Homer, B. D., & Um, E. (2014). Emotional design in multimedia learning: Effects of shape and color on affect and learning. *Learning and Instruction, 29*, 128-140,. doi: ISSN 0959-4752)

Quinn, C. (2000). *Mobile Learning: Mobiles, Wireless, In-Your-Pocket Learning.* LiNEZine.

Szapkiw, A. J., Courduff, J., Carter, K., & Bennett, D. (2013). Electronic versus traditional print textbooks: A comparison study on the influence of university students' learning. *63*, 259-266.

Tabuchi, H. (2011, January 9). Facebook Wins Relatively Few Friends in Japan. *New York Times*.

Wang, M., & Shen, R. (2012). Message Design for Mobile Learning: Learning Theories, Human Cognition and Design Principles. *British Journal of Educational Technology, 43*(4), 561-575.

Zywno, M. S. (2003). A contribution of validation of score meaing for Felder-Soloman's Index of Learning Styles. *Proceedings of the 2003 Annual ASEE Conference.*