General research problem

How may instruction be improved?

The National Center for Education Statistics (n.d.) estimates that 56.6 million students will attend public K-12 schools in fall 2019. Others will attend college, enroll in a trade school, or receive private instruction. Technology can replace face-to-face instruction with devices, websites, or digital interfaces through which an instructor communicates. Critics claim that remote instruction is "not a real dialogue" and cannot create "intellectual joy" (Edmundson, 2012). Proponents claim advantages including a "flexible schedule and environment" and "Lower costs and debts" for students (Ed Technology, n.d.).

Automated piano tutor

How can piano instruction be automated?

The capstone project advisor is Prof. Harry Powell of the Department of Electrical and Computer Engineering. The collaborators are Mert Karakas, Nate Geerdes, and Eddie Russel.

Traditionally, piano instruction is partially comprised of in-person lessons that provide instant feedback on students' play. While beneficial, lessons can be prohibitively expensive; 29% of surveyed UK children who had never learned an instrument had not done so because of the cost of learning (ABRSM, 2014). Students can forego the use of an instructor but will lack the feedback essential to developing a musical foundation. Automating piano instruction would enable students to receive this foundation-building instruction without an instructor. This could turn the average cost of $40 per piano lesson (K, n.d.) into a fixed device cost while providing feedback techniques that a traditional instructor would find challenging to implement. It could also re-shape how students view their lessons through processes such as gamification, motivating

those who would otherwise be uninterested in learning to play an instrument. Students who prefer to have in-person lessons may still utilize automated instruction to enhance practice sessions.

The goal of the project is to use the group's ECE knowledge to construct a device that will teach users to play piano songs. The solution must include an embedded device and a printed circuit board. Current solutions on the market indicate to the user which keys to play next and determine if they played the correct notes to advance the song. They do so with a MIDI connection cable (Pianu, n.d.), light-up keys built into the piano itself (Become Singers, 2019), or lasers that track which key the user is pressing down (theONE, n.d.). These options either require the user to have a digital keyboard or make use of a costly array of lasers. This project will differ by being compatible with any piano, digital or not, while using a cheaper method to identify the keys a student is pressing involving pitch identification algorithms. It combines the cost-effectiveness of the MIDI or light-up option with the flexibility of the laser option.

We will implement a basic pitch identification technique in LabView and run the algorithm on a myRIO embedded device, making use of the built-in field-programmable gate array to perform calculations quickly. Feedback will be provided with a microphone, myRIO, and LED strip. Songs to be learned will be uploaded to the device in MIDI file format via USB connection. Testing will be done by attempting to learn songs with the device and evaluating pitch detection ability, feedback delivery, and ability to teach the user to play.

If we succeed, we will have the previously mentioned algorithm and device. Because feedback is based on pitch, the algorithm may be repurposed for other devices that provide feedback for different instruments.

Moving college to the web: the push for online higher education.

How are teachers, students, educational institutions, publishers, and educational tech developers competing to influence the instructional technology of college classes?

In 2019, about 200 million students are enrolled in higher education programs around the world (World Bank, n.d.). Educational technology can supplement or replace classrooms. Three-fourths of surveyed educators said they already use new technologies in some way (Sabo, 2019). Investors have been quick to notice this change; in 2018 educational technology providers raised $511 million to fund development related to postsecondary education (Wan, 2019). Social groups are competing to determine how tech will be applied in higher education.

Scagnoli et al. (2019) found that students thought video lectures were a "positive overall learning experience" and could "enhance a feeling of engagement" with the material. Arora et al. (2013) found that engineering students earned significantly higher scores on final exams when they completed homework online rather than on paper. Van Camp & Baugh (2014) found that 55% of survey-responding students said Pearson Education's educational technology helped them earn better introductory psychology grades and 70% said it helped them earn better test grades. Jonas & Norman (2011) found that students with access to optional online educational resources for class tended not to use them unless required to do so by their instructor.

Pearson, a textbook publisher, claims it seeks to "improve access and outcomes in education" by "combining expert content and assessment, powered by our services and technology" (n.d.). Because Pearson's books are online, however, students "can't resell them once they're done with the course" (McKenna, 2018). The Mathematical Association of America supports webwork, an open-source system "with the goal of providing the mathematical community with the most robust, flexible, and mathematically capable online homework system

possible" (MAA, n.d. (a)). MAA quotes students as saying "WebWork is the only way that I can push myself to really do something about the homework," and "immediate feedback makes sure you have accomplished something" (MAA, n.d. (b)).

Some high school students oppose online college education. An ACT poll (n.d.) found that 48% of college-bound high schoolers "wanted to take none of their classes online" and 80% agree that "Traditional classroom programs offer a higher quality academic experience." ACT posits that most students value a "traditional college experience" including in-person discussion and faculty relationships. Virginia Tech (n.d.) claims that its educational computer lab, the math emporium, will "encourage collaborative work," helping a student to "grow more reponsible for his own learning." A writer for *American Higher Education* says that "saving the university money" and not "putting anyone with a pulse in charge of a class" are other reasons behind the emporium (Mills, n.d.).

Online educators affiliated with the MSc in E-learning programme at the University of Edinburgh published a manifesto asserting that "distance is a positive principle" and "online teaching should not be downgraded into 'facilitation'" (SWOP, 2011). They reject the idea that e-learning should be described "in terms of replication of offline practices, or in terms of inadequacy." Instructors in California have formed the nonprofit group Computer Using Educators, professing that "technology is a critical instructional resource required for all K20 teachers, administrators, and students" (2014). They advocate for "support of underserved areas," "administrative uses of technology," and "fully funded professional development." The National Education Association contends that "Online teaching can be a boon for teachers themselves" but that millennial learners "see little significant use of technology to extend their classroom learning" (n.d.). The guide recommends that states "Ensure that state licensure

requirements accommodate online courses" and "Expand professional development programs to prepare a cadre of educators who can effectively instruct online."

Inside Higher Education's 2019 poll found that most professors "oppose colleges' use of external vendors to deliver online academic programs" but that 46% of professors have taught an online course for credit (Lederman). The same poll found that 36% of professors disagree that "online courses can achieve student learning outcomes at least equivalent to in-person courses at any institution," while 32% agree.

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