Opportunities and Challenges in Creating, Adapting, & Adopting OER Material in ET Programs

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Abstract

Open educational resources (OER) are teaching and learning resources in the public domain and have been licensed in such a way that anyone can freely use and re-purpose them. OER can be any materials or tools used to support learning, including course materials, modules, textbooks, lesson plans, streaming videos, hands-on laboratory manuals, test questions, etc. Studies at both the K-12 and higher education levels show that students who use OER do as well, and often better, than their peers using traditional resources.

In this paper, we share our experience of creating multi-media learning material for a junior level sensors and applications course, the technology we used to create and share the OER material, and the resources and support needed. We also share our vision of sustaining OER as a trust-worthy live document that faculty and instructional delivery staff can contribute to and adapting for their student population. Its lifecycle and process is similar to those of many of the successful open-source software and platform.

1. Introduction

Research and federal reports published in the last decade pointed out that the higher education system needs to transform to better serve the society and our future. The context of higher education has been changing in the last couple of decades, not only because of our student population is getting more and more diverse, but also due to the advances in education technology that can support better instruction pedagogy. According to Pew survey in May 2019 (Pew 2019), total share of students from low-income backgrounds in our undergraduate college student population increased from 12% in 1996 to 20% in 2016. Same report also documented that the share of students of color increased from 29% to 47% during the same period. This happened while the confidence in Higher Education (Gallup 2018) decreased on average 9% from 2015 to 2018, based on survey of U.S. adult. Figure 1 summarizes the results from both survey studies.

In recent years, natural and manmade disruptions throw additional challenges at the education system, and in particular institutions of higher education (IHEs). At the same time, many IHEs are either planning or taking advantages of the circumstances and using the opportunity to either start or deepen their transformation process, including many Engineering Technology programs. Given that the graduates from the Engineering Technology programs are the backbone of a functional technology-advanced society of the future, it is especially urgent for us to lead the transformation effort and create equitable and high quality learning environment and experiences for our students.

Non-traditional Students % (Pew 2019)			
	Low Income (In or Near Poverty)		Non-White
	Dependent*	Independent	
1996	29		29
2016	39		47

Confidence in Higher Education (Gallup 2018) (% for "a great deal" or 'quite a lot')			
	2015	2018	Change
	%	%	Pct. pts
US. adults	57	48	-9
Democrats	68	62	-6
Independent	48	44	-4
Republicans	56	39	-17

* Dependent student's income-to-poverty ratio is based on the income of the student's parents. Independent student's ratio is based on the student's income.

Fig. 1. Dual pressure direction for higher education. (Adapted from Pew and Gallup National Survey Reports).

The New Learning Compact (Bass 2019) provides an overarching framework for learning-centered transformation. It calls for developing excellent teaching and support for quality instruction by focusing on four dimensions (core values, core principles, inquiry & analysis, and integration of professional learning and educational development) at multiple scales (Individual – Community – Institution – Ecosystem) within the IHEs. Figure 2 shows the vision of NLC and its four dimensions and four scales.

NLC provides an integrated platform for all those evidence-based high-impact practices (HIPs) that demonstrated positive effect on students learning and sustained success. Creating and adopting open educational resources (OERs) fulfills the core values of NLC – "Inclusive and Equity-Focused" and "Learning-Centered" – and supports the HIPs including project-based learning (PBL), to collaborative projects, to undergraduate research, and much more.

2. Benefits OER Brings for Students, Faculty, and Programs

Given the ever-accelerating speed of technology advances in the last couple of decades, creating and using open educational resources (OER) that can be updated and adapted in a timely manner is essential for our students and learners alike nowadays.

As educators in engineering technology (ET), we have been creating and updating our lab material to better tailor to the commercially available hardware and software platforms and balance the theory and praxis in the students learning process. In recent years, with the proliferation of various learning management systems (LMS), many of our lesson plans, lecture notes and slides, as well as recorded lecture videos and additional learning reinforcement activities are made available online to provide flexibility for students to review the material and clarify any misunderstanding. Research and anecdotal evidences showed that all these additional educational resources improved knowledge retention and reduced misconception among students. It also illustrated the insufficiency of the traditional textbooks. On the other hand, as a "living" document, OER provides much needed flexibility to incorporate and integrate current advances in technologies and instructional pedagogies, applications and case studies in the field in a timely fashion.

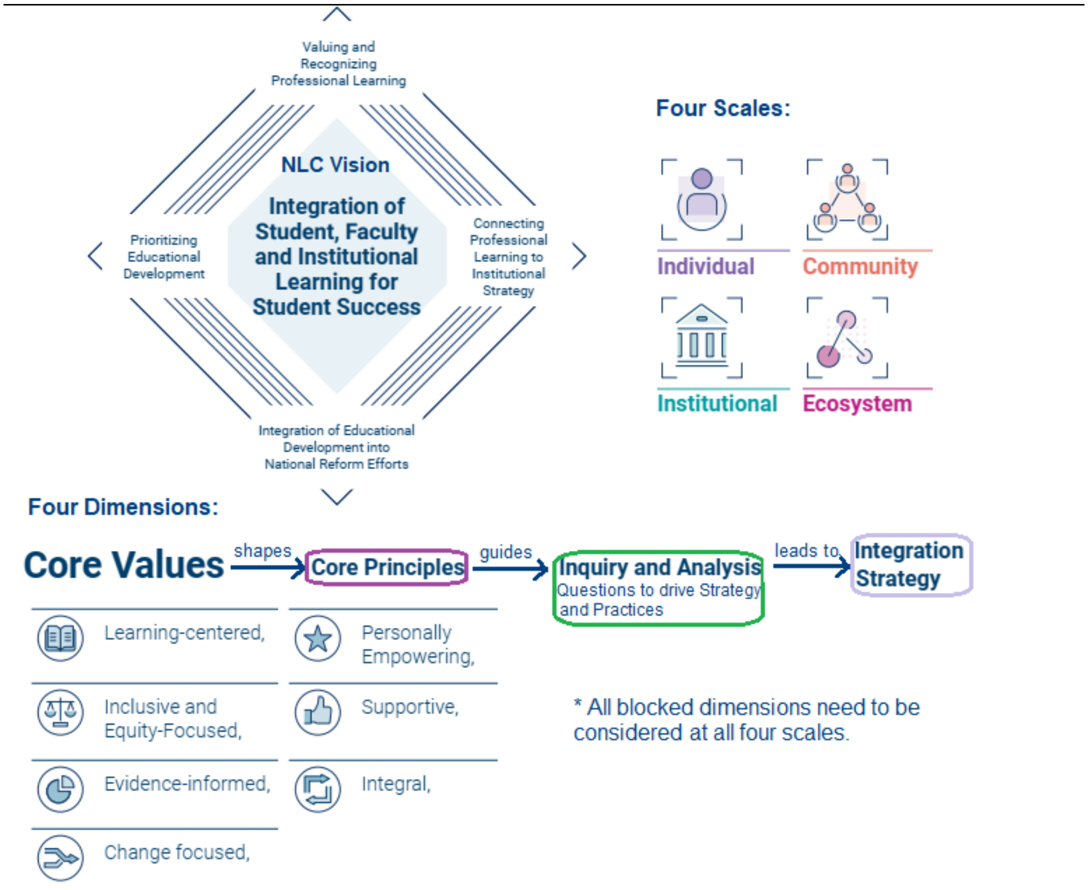

Fig. 2. New learning compact (NLC): Vision, four dimensions, and scales. (Adapted from Bass 2019).

In addition, OER allows educators to mix-and-match learning material from existing OER material to fit the needs of their students. Combined with existing LMS platforms, we can put all necessary multi-media learning material in one place – with links to extra material – and make the learning process smoother, thus ensuring students early engagement in their learning process.

By integrating new digital learning functions (such as web annotation) that many OER publishing platforms support, we orient students towards real-world applications (i.e., case studies) that have big social-economic impact and motivate them to move towards higher levels of learning according to Bloom's Taxonomy (Bloom 1956) and form life-long learning mindset.

Nowadays more and more students in IHEs are classified as "non-traditional" — those who are not entering university right after their high school graduation and needing to work part- or full-time job(s) to pay for their higher education. Most of the time, the tasks they do and functions they perform at work has little to do with the subject they choose to study. With the associated cost-saving, creating and adopting OER aligns with the IHEs mission of improving the diversity, equity, and inclusion of high education by allowing all students access to the learning material, regardless of their socio-economic standing. Integrating of OER and LMS also provides each of these non-traditional learners accountability when they tailor the learning progress to their own circumstance.

There is no doubt that more research needs to be conducted for us to fully understand and appreciate the benefit of high quality OER and discover the relation between high quality OER and high-performing graduates who can contribute positivity to the future society.

3. Support and Resources Needed for OER

There are many challenges for faculty to create, adapt, and adopt OER learning material. The success of such effort not only require resources at university and departmental levels but also support from the academic community within a particular IHE and nationwide.

For example, at the University level, an OER adoption platform that integrates with existing textbook adoption platform would make adopting OER material easier and seamless for both faculty (OER creator and adaptor) and students. Furthermore, potential OER creator and adaptor will be encouraged and incentivized if the institution also supports the integration effort between the OER adoption platform and the existing instruction delivery and learning management system (LMS). When such option is not available, at university level, sufficient policy and technical support are needed for the OER creator and adaptor to manually integrate these two systems. At the department and program level, new policies that facilitate and support OER creators and adopters are needed to incentivize faculty to take on the effort.

Align with the institution's goal of student success, university library would be a good host to lead the effort and provide guidance regarding choosing and effectively using OER creation platform, copyright and licensing process (e.g., Creative Commons license), and the kind of assessment tool and rubrics faculty can use when developing, adapting, and adopting OER material. Given the fast development in assessment from multi-facet at multi-levels, the library can also serve as quality gate-keeper for the OER created on campus as well as influx of OER material.

Assume that program and educational unit are backing the creation and adaptation of OER material, faculty still need to decide on the format and types of OER resources to create or adapt, the assessment rubrics and tools to support students learning, as well as the mechanism to integrate with existing instructional delivery and LMS practices for their courses. We list some of the questions creators need to ask themselves before taking on such effort.

- What type of OER to create/adapt: textbook, learning modules, hands-on experiments, or videos?
- What kind of copyright protection and licensing are needed? Does the institution provide guideline for such?
- What is the expected timeline for the effort?
- Is there process setup for continuous improvement at the program and institutional levels?
- Is there sufficient technical support for effectively utilizing the OER platforms and integrating it with existing LMS the educational institution uses?
- Is there available assessment rubrics and tools that can be used for the developed OER or new rubrics and tools need to be created, as detailed in the previous section.

The case study in the next section will provide some examples regarding all these questions.

4. Case Study: Creating OER for Junior Level ET Course

Our program has been offering a junior level course on Sensors and Applications (referred to as sensor course in the following text) for quite some time. For the last decade, the need to update its textbook and supporting learning material and resources is getting more and more urgent due to multifaceted change factors. This includes but not limited to the advances in science and technology, the diversification of our student population and their learning style, the developing of instructional delivery and learning management software platforms, and the ever-expanding application areas for automation systems that can take advantage of an effective and efficient high performing data acquisition system.

We designed the course originally to integrate the operational amplifier (OpAmp) circuits into the signal conditioning function of the data acquisition system to introduce system-level thinking to our students. It combines a sophomore level OpAmp course with a junior level course on instrumentation and measurements and fulfills the updated accreditation credit hours requirement. The course exposes students to the design & implementation process of a computer-based automation system that requires the integration of both hardware and software components. After students mastered the data acquisition part in this course, they will learn about embedded systems focusing on control strategies in subsequent courses. Figure 3 shows the synopsis of the course description.

The course covers characteristics of a SCADA system and how to evaluate its static and dynamic performance, analog and digital signal conditioning circuits that connect sensors to micro-processor based control systems, including Op-Amp circuits and ADC/DAC; principles of thermal, mechanical (motion, force, and flow), and optical sensors; and interfaces between these components. Students will also learn the graphical based application development environment popular in industry, and work in teams to create DAQ system for a particular application identified through research. Student

teams will communicate the findings through written report and oral presentation & demonstration.

Fig. 3. Course description: ELET 3403 Sensors and Applications.

With federal funding, we designed 20 hands-on experiments and used six at the component level and five at the system level in the course to revamp its laboratory section (Moges2007, Moges 2008, Yuan2009, Yuan2013). All the lab manuals have been reviewed, updated, and shared with students for free every year. The topics for medium scale project based hands-on experiments are used to start up the brainstorm session of student teams for their course final project. Figure 4 shows the list of experiments incorporated into the course and the final project topics.

Component Level	Final Project Topics
1. Analog Circuits Fundamentals (RC circuits frequency response, Multisim Workbench): PreLab and Lab Manual 2. Analog Power Source Fundamentals (VCCS, CCVS):PreLab and Lab Manual 3. Analog Signal Conditioning Fundamentals:PreLab and Lab Manual 4. Thermistor and First Order Time Response:PreLab and Lab Manual 5. Thermocouple based Temperature Measurement System:PreLab and Lab Manual 6. Mechanical Sensor Fundamentals: Strain Gauge and Load Cell:PreLab and Lab Manual	- Indoor ambient environment and activity monitoring system -Wireless DAQ for smart vibration platform system -Home Environment Monitoring and Control
System Level	
1. Introduction to software developement enviornment: LabVIEW and VI construction:PreLab and Lab Manual 2. Measurement and Instrumentation Fundamentals:PreLab and Lab Manual 3. Programmable System on Chip (pSoC) Fundamental:Lab Manual 4. Digital Fundamentals: Implement comparator and ADC/DAC using pSoC: PreLab and Lab Manual 5. Digital Fundamentals: Build LCD Display using pSoC:PreLab and Lab Manual	

Fig. 4. Component level and system level hands-on experiments.

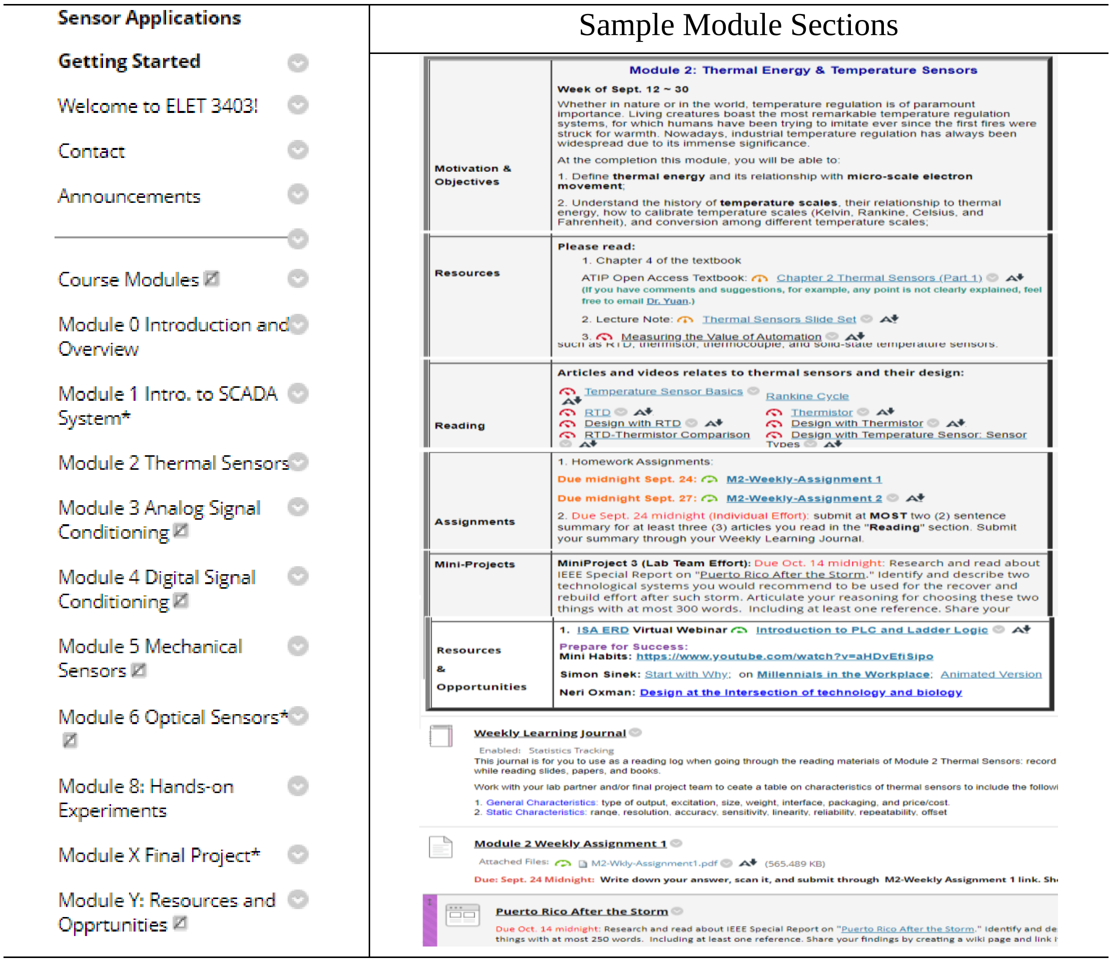

Fig. 5. BBLearn course setup for sensors and applications.

For the last decade, most if not all of the IHEs adopted learning management systems (LMS) to support students learning and provide collaborative and assessment tools for instructors to interact with students and for students to collaborate on their projects. Popular LMS includes Canvas (Canvas2022), Moodle (Moodle2022), and Blackboard (Bb) (Bb2022). Our sensor course migrated onto the Blackboard platform and then transitioned to Blackboard Learn system in the last decade. We started by adapting the face-to-face lecture notes to online lectures. Since then, we made continuous improvement by adding more multi-media material regarding recent development and new applications, as well as reinforcement activities like learning and practicing research and professional skills. Figure 5 shows the setup of the learning modules of the course offered face-to-face before COVID with integrated LMS to share learning material, facilitate students team collaboration (using Bb Tool Wikis), and instructor-student interaction (using Bb Tool Journals). Each learning module focuses on one subject topic and separate into sections from Learning Objectives, to Readings, to Assignments, to Mini-Projects, to Resources & Opportunities. The hands-on experiments and final project have their own learning modules since they need separate educational resources, as shown in Figure 6.

Hands-on Experiments Module	Final Project Module

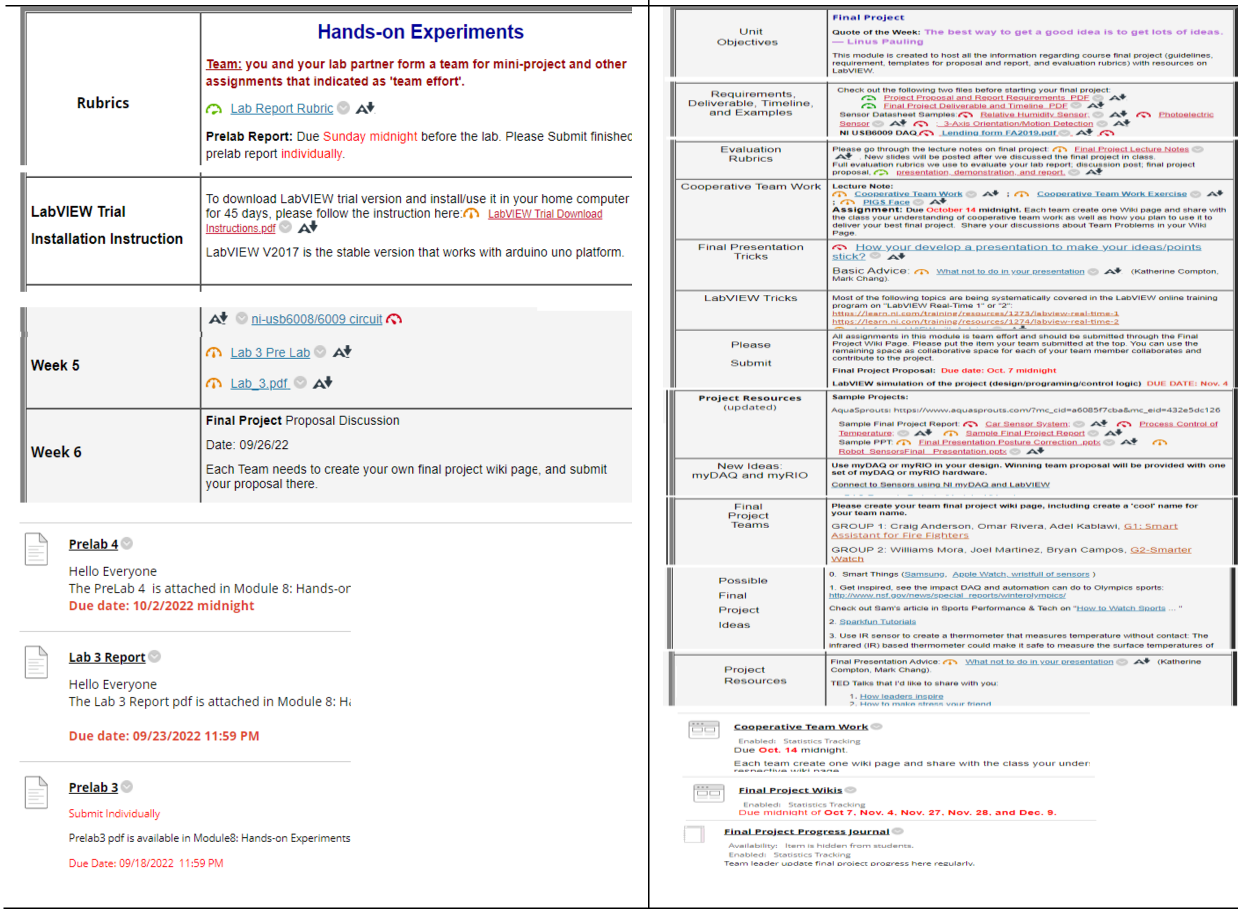

Fig. 6. BBLearn course: Hands-on experiment & final project modules.

COVID-19 provided opportunities for us to record the lecture and lab demonstration, further enrich the learning material. Figure 7 gives a glimpse of the course library of lecture recordings in the MS TEAMS setting that allows students to review and clarify the topic after class.

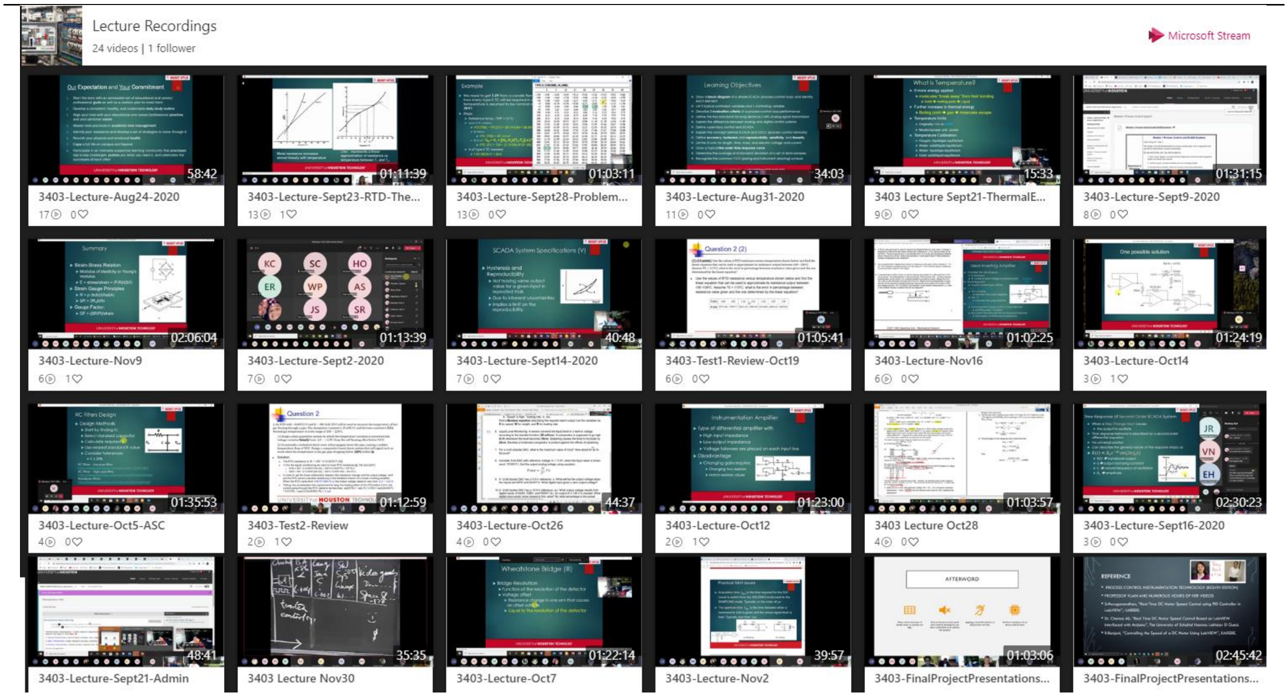

Fig. 7. Lecture recordings library in MS TEAMS

Since 2018, our library started the Alternative Textbook Incentive Program (ATIP) to incentivize creating more OER material with a small grant. The instruction team decided to create a textbook integrating all new material and multi-media resources that support active learning activities in 2019 and was selected as one of the 2020 ATIP project cohort. The team went through training on utilizing Pressbooks (the platform university choose for OER publishing) and licensing (e.g., open licensing like creative commons) during Spring and Summer 2020 and started the creation process in Fall 2020.

Despite all the disruptions, we started sharing our OER textbook draft with students in Fall 2022, with the expectation that we will continue using Blackboard for slides sharing, assignment and report submission, and basic structure for instructional delivery. We are also using MS Teams to provide a collaboration platform for students project, and interaction platform for instruction team and students. In fact, we are able to provide more flexible office hour to support our students learning throughout the weekdays and weekend.

The OER textbook we are creating covers more topics relevant to current automation technologies with their expanded application areas. As mentioned before, the textbook also includes learning objectives for each chapter, aligning with the recent ABET accreditation criteria. Figure 8 shows the structure of the textbook. We hope to share it with all teaching and learning community in ET and make it a living documents to benefit more students and programs.

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Fig. 8. Structure of ATIP OER textbook.

5. Conclusion & Future Direction

ET programs have long history of creating and offering lab manuals of the hands-on experiments free or at very low cost for the working-class students we are serving. The content and structure of such learning material (manual) have been continuous improved to better facilitate student learning in the digital era, moving from traditional recipe-style "step-by-step" instructions towards project-oriented design challenges that facilitate inquiry and discovery-based learning-by-doing process. The current OER movement expands such effort towards all kinds of learning resources that encompassing diverse media and ensuring the quality, equality, and inclusivity of the education ecosystem.

We may want to take advantage of the movement and revamp not only how the "boring" technical content are introduced to our students – often for the first time, how students access such content, how their curiosity for learning can be sustained, but also provide personalized guidance and accountability measure at the right time. The goal is to not overwhelm any learner with too much new concepts and knowledge. Instead of paralyzing their desire to learn, the OER can facilitate their learning by informing them when they are ready to move to deeper and more complex topics.

In conclusion, in order to realize potential benefits of creating and adopting OER to support students learning, we need a strong, diverse and committed community consists of faculty, librarian, supporting staff (e.g., instructional delivery and IT), and administrators at program, departmental, college, and university levels. Once we setup the basic supporting infrastructure for the OER ecosystem within academic and education community, we need to rally more OER content development and standardize and streamline the distribution and sharing channels to benefit all students around the country and the globe. At the same time, research projects are urgently needed to study systematically the most effective model and mechanisms to choose proper OER for individual learners. Given the track record of various ET programs around the country, it is the time for us to lead the effort to benefit our students and deepen our partnership with industry.

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