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PathFinder: Affordable and Effective Web-books for First Year Engineering Courses

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Full Paper: PathFinder: Affordable and Effective Web-books for First Year Engineering Courses

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Jess W. Everett has worked in four distinct areas: waste management operations research, contaminated site assessment and remediation, education innovation, and sustainable engineering. He has employed a wide variety of techniques, including computer modeling, laboratory experiments, field testing, and surveys. His current research focuses on energy conservation, alternative energy generation, engineering learning communities, and hybrid courses (courses with classroom and on-line aspects).

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Dr. Scott Streiner is an assistant professor in the Experiential Engineering Education Department (ExEEd) at Rowan University. He received his Ph.D in Industrial Engineering from the University of Pittsburgh, with a focus in engineering education. His research interests include engineering global competency, curricula and assessment; evidence-based teaching practices and curricular innovations applied to misconceptions; and game-based learning. His funded research explores the nature of global competency development by assessing how international experiences improve the global perspectives of engineering students. His dissertation investigated how best to design and operationalize effective global programming strategies within engineering curricula. Dr. Streiner has published papers and given presentations in global engineering education at several national conferences. He has a passion for data analysis and has taught classes in probability and statistics, and teaches Freshman Engineering Clinic at Rowan University. Scott is an active member in the Center for the Integration of Research, Teaching, and Learning (CIRTL) both locally and nationally, as well as the American Society for Engineering Education (ASEE) and the Institute of Industrial and Systems Engineers (IISE).

Full Paper: Affordable Effective Web-books for Introductory Engineering Courses

PathFinder Web-books

The PathFinder web site (https://pathfinder.rowan.edu) is supported by a group of engineering professors at a public four-year university in the northeast. PathFinder professors are interested in providing affordable, but effective, web-books to students. The purpose of this paper is to describe PathFinder and promote a discussion concerning affordable web-books in first-year engineering classes via PathFinder or similar website. PathFinder is different from other Learning Management Systems--e.g., Backboard, Moodle, Canvas, etc.--because it provides a platform to: (1) grow a database of course content in modular form; (2) use that database to create custom web-books; and (3) disseminate affordable custom web-books. When PathFinder is used in courses with multiple sections, such as Introduction to Engineering courses, it ensures common readings, quizzes, & homework and can be used to recommend in-class activities. PathFinder is currently used at one 4-year institution and two nearby community colleges; however, any professor/institution can adopt PathFinder web-books.

User and Content information is stored in folders on the PathFinder website (Figure 1). Professors use the PathFinder website to create, maintain, and access content folders. Each folder contains information on a simple concept. A folder contains a name and description and may contain an article, class activities, variables, equations, exercises, images, videos, exercises, and/or references. Articles may pull information from its own folder or other folders, e.g., references, images or equations. Chapters are folders with an article that pulls content from multiple content folders to communicate complex topics. A web-book is a file residing in a professor's folder that aggregates multiple chapters, associates exercises with each chapter, and includes students in the web-book's class.

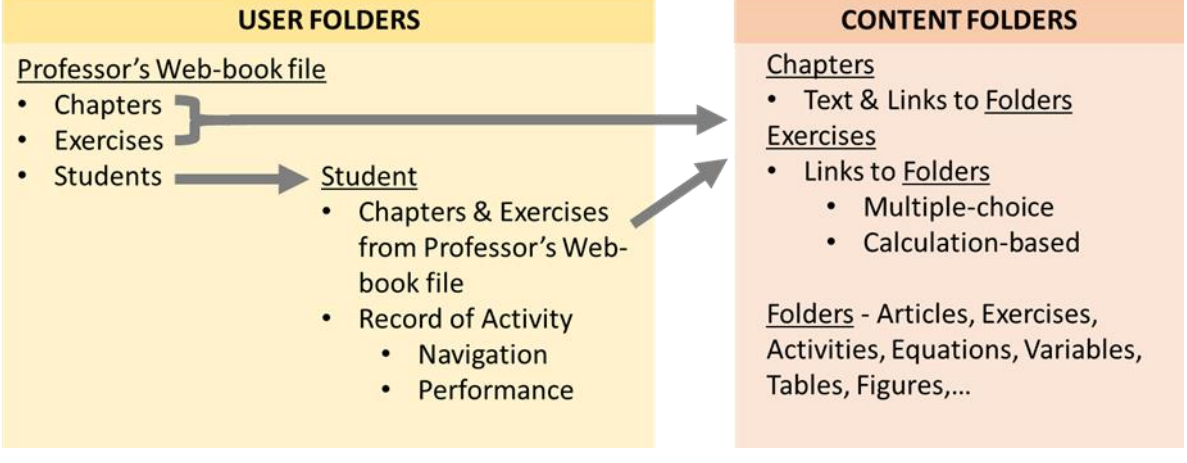


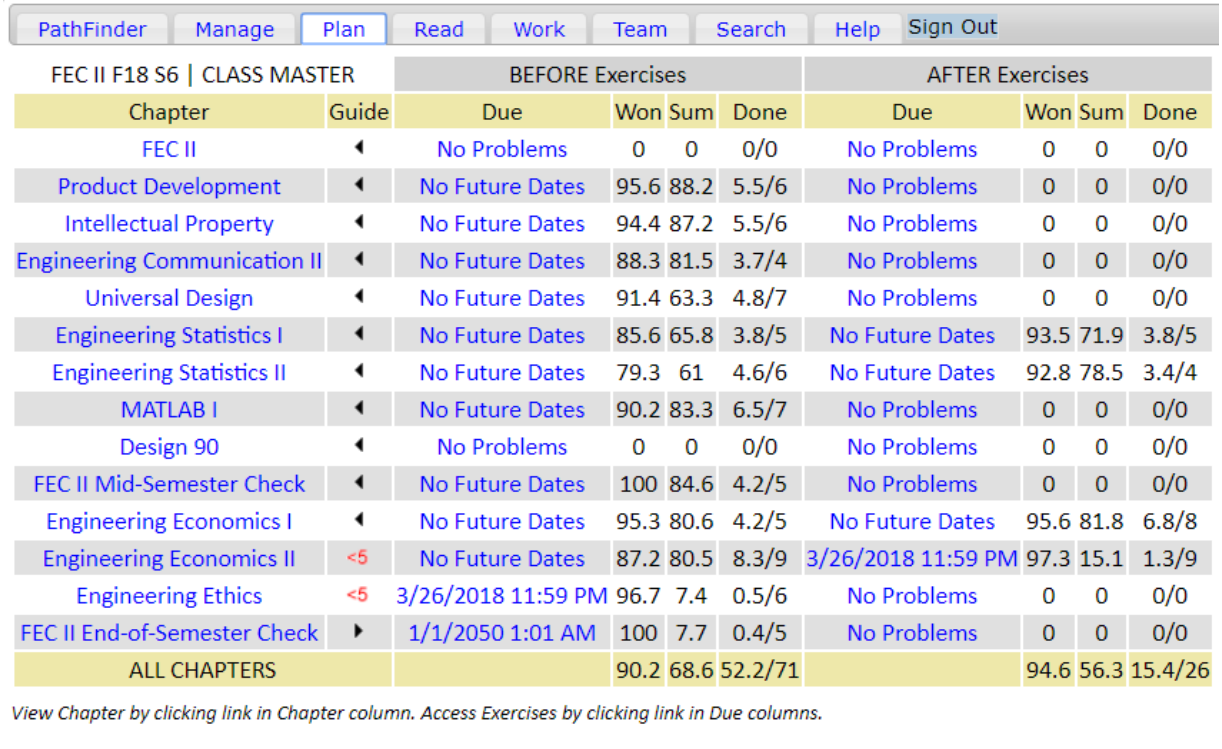
Figure 1: PathFinder Organization

Students access PathFinder web-books via the Internet to read content and complete quizzes and homework. When a student accesses a web-book chapter, PathFinder assembles content on the fly from the latest and most up-to-date content in its folders. Students navigate chapters by

scrolling or using links to jump to any heading, table, figure, equation, or example. Chapters are associated with BEFORE and AFTER exercises. Students complete BEFORE exercises before the professor covers the associated chapter in class; thus, PathFinder promotes the flipped classroom approach to instructional practice. Students complete AFTER exercises after a chapter is covered in class, i.e., AFTER exercises are homework.

Exercises can be multiple-choice or calculation-based. They are chosen from banks, so each student is assigned a different set of exercises. PathFinder randomly selects the input values of calculation-based exercises, so even when two students are assigned the same exercise they cannot simply copy answers. Most calculation exercises have an associated practice problem student can explore before attempting the scored exercise. Exercises are graded automatically, freeing graders to spend more effort on higher-level assignments, e.g., more sophisticated or open-ended exercises or reports.

Figure 2 is a screenshot of the PathFinder Plan Tab for a Spring 2018 Freshman Engineering Clinic II (FEC II) web-book at a public university in the northeast. FEC II is a second semester engineering course that introduces students to fundamental engineering concepts such as customer-focused design principles, statistics, engineering economics, and engineering ethics. It is the second in a sequence of four interdisciplinary, hands-on, project-based courses that introduce engineering to students.



PathFinder | Manage | Plan | Read | Work | Team | Search | Help | Sign Out

FEC II F18 S6 | CLASS MASTER		BEFORE Exercises				AFTER Exercises			
Chapter	Guide	Due	Won	Sum	Done	Due	Won	Sum	Done
FEC II		No Problems	0	0	0/0	No Problems	0	0	0/0
Product Development		No Future Dates	95.6	88.2	5.5/6	No Problems	0	0	0/0
Intellectual Property		No Future Dates	94.4	87.2	5.5/6	No Problems	0	0	0/0
Engineering Communication II		No Future Dates	88.3	81.5	3.7/4	No Problems	0	0	0/0
Universal Design		No Future Dates	91.4	63.3	4.8/7	No Problems	0	0	0/0
Engineering Statistics I		No Future Dates	85.6	65.8	3.8/5	No Future Dates	93.5	71.9	3.8/5
Engineering Statistics II		No Future Dates	79.3	61	4.6/6	No Future Dates	92.8	78.5	3.4/4
MATLAB I		No Future Dates	90.2	83.3	6.5/7	No Problems	0	0	0/0
Design 90		No Problems	0	0	0/0	No Problems	0	0	0/0
FEC II Mid-Semester Check		No Future Dates	100	84.6	4.2/5	No Problems	0	0	0/0
Engineering Economics I		No Future Dates	95.3	80.6	4.2/5	No Future Dates	95.6	81.8	6.8/8
Engineering Economics II	<5	No Future Dates	87.2	80.5	8.3/9	3/26/2018 11:59 PM	97.3	15.1	1.3/9
Engineering Ethics	<5	3/26/2018 11:59 PM	96.7	7.4	0.5/6	No Problems	0	0	0/0
FEC II End-of-Semester Check		1/1/2050 1:01 AM	100	7.7	0.4/5	No Problems	0	0	0/0
ALL CHAPTERS			90.2	68.6	52.2/71		94.6	56.3	15.4/26

View Chapter by clicking link in Chapter column. Access Exercises by clicking link in Due columns.

Figure 2. PathFinder Dashboard - Freshman Engineering Clinic II, section 6, 3/22/2018

Users access web-book chapters via links in the Chapter column on the Plan Tab (Figure 2). The chapter opens in the Read Tab and associated exercises appear on the Work Tab. Users can also access chapters and exercises by clicking links in the Due columns (opening exercises in the

Work Tab, with the associated chapter appearing on the Read Tab). The Due columns text show future due dates. The Guide column indicates a future due date with a right pointing triangle and counts down by day within a week of a due date. The Won and Sum columns display to professors the average percentage of points awarded for completed (Won) and all (Sum) problems, for all students in a course section. The Done column displays the average number of problems completed by the students. Students see their own results on their own Plan Tab.

Figures 3 and 4 are used to show PathFinder chapter code (Figure 3) and the resulting visual chapter representation (Figure 4). The code starts and ends with html specific to the web-book: a section header and introductory sentence (start) and a comment for students in the web-book's course (end). In the middle are two links, [[1c,102]] and [[1e,102,1]]. The first causes PathFinder to insert the article describing a sample mean. The second causes PathFinder to add html describing an example problem. Both links cause PathFinder to read another content folder to obtain the required information. The sample mean article also contains a link to an equation. The equation contains links to three variables. These could be in the sample mean content folder or some other folder.

```
<h3>Sample Mean</h3>
<p>The mean is a measure of central tendency, a middle point of a sample or population.</p>
[[1c,102]]
[[1e,102,1]]
<p>&#9755; <i>Want to change the look of equations in PathFinder? [Right-click] on an equation with your mouse and select 'Math Settings'. 'Zoom Trigger' and 'Zoom Factor' allow you to zoom equations when you click or hover over them. 'Math Renderer' allows you to change how your browser displays equations. Select your preferred settings by experimenting with equations 1 or 2.</i></p>
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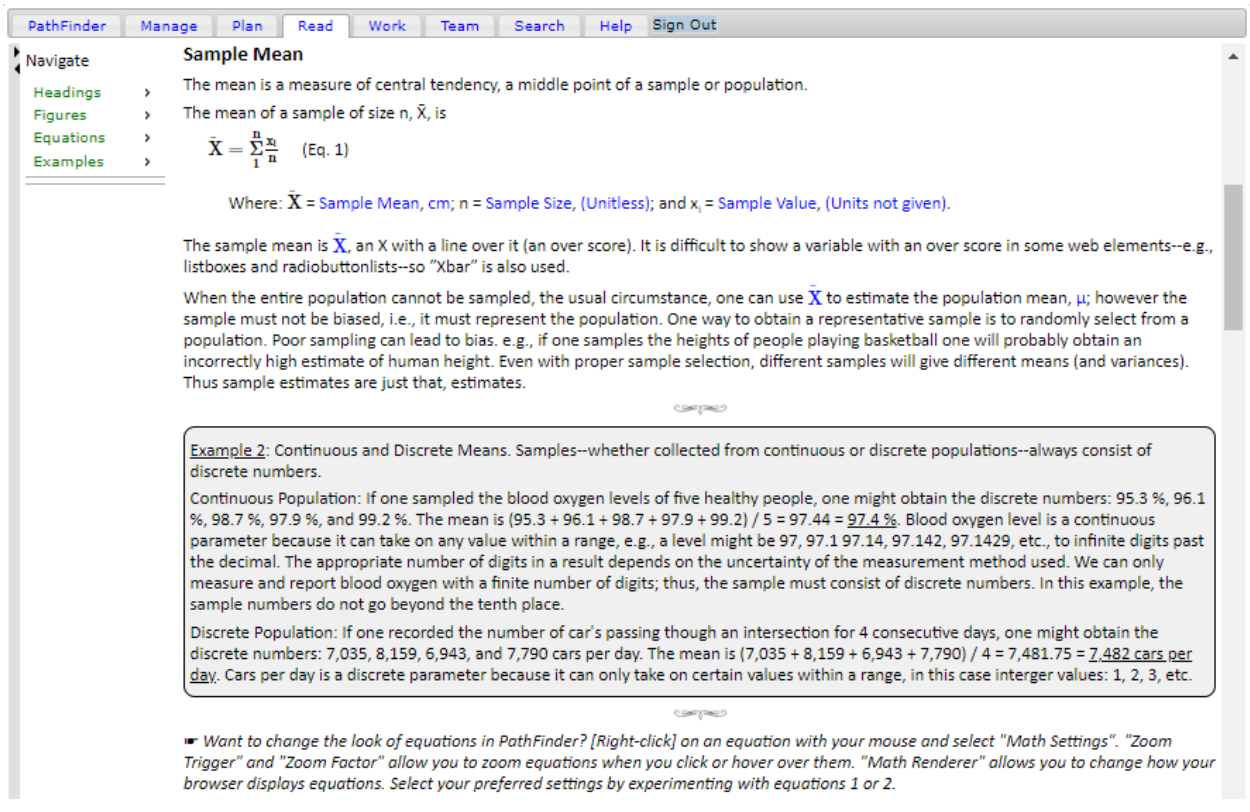
Figure 3. PathFinder Chapter Section Code

The resulting chapter display is shown in Figure 4. The navigation menus are in the upper right in green text. Under the 'Headings' menu, 'Sample Mean' was selected to create Figure 4. Alternatively, 'Equation 1' or 'Example 2' could have been selected under other navigation menus to put the equation or example at the top of the display window. All of the content between the introductory sentence and the italicized text was created on the fly from the two PathFinder links described above. If the content in the 'sample mean' content folder was changed, the next time a student accessed this chapter, the display content would differ accordingly. PathFinder displays equations, such as equation 1 in Figure 3, using MathML (https://www.matml.org) and MathJax (https://www.mathjax.org).



(b)

Figure 4. Resulting Chapter Section Display

Example multiple-choice and calculation exercises are shown in Figures 5 and 6, respectively. They are accessed on the Work Tab. Most BEFORE exercises are multiple-choice. Most AFTER exercises are calculation-based. Figure 4 includes the solution to the AFTER exercise. Before completing a given step of a problem, students see a textbox and submit button for that step. The solution is only displayed for completed steps.

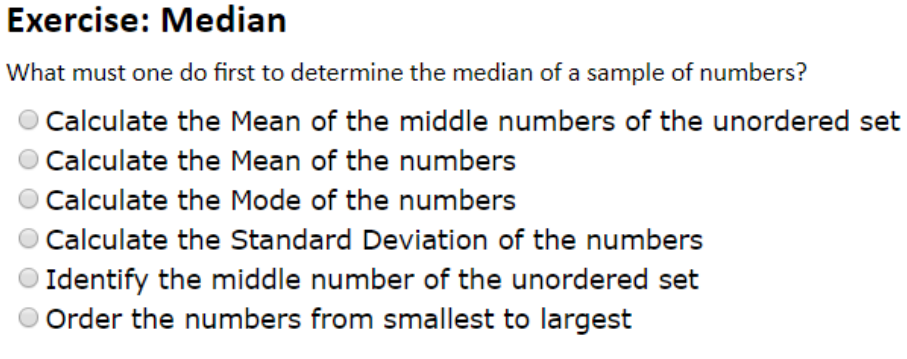


Figure 5. Example Multiple-Choice Problem

Exercise: Sam Param 1

Determine Sample Parameters from a sample of size 5

Given

The five possible values are:

X_1 = 3.33 cm

X_2 = 6.18 cm

X_3 = 10.0 cm

X_4 = 12.0 cm

X_5 = 17.4 cm

Question(s)

1. Determine the sample mean, $\bar{X}$.

   Answer: $\bar{X} = \frac{3.33\ \text{cm}+6.18\ \text{cm}+10.0\ \text{cm}+12.0\ \text{cm}+17.4\ \text{cm}}{5}$ = **9.78 cm**

2. Determine the sample median, m.

   Answer: $\text{m} = 10.0\ \text{cm}$ = **10.0 (Units not given)**

3. Determine the sample variance, s^2.

   Answer: $s^2 = \frac{(3.33\ \text{cm}-9.782000\ \text{cm})^2+(6.18\ \text{cm}-9.782000\ \text{cm})^2+(10.0\ \text{cm}-9.782000\ \text{cm})^2+(12.0\ \text{cm}-9.782000\ \text{cm})^2+(17.4\ \text{cm}-9.782000\ \text{cm})^2}{5-1}$ = **29.4 cm²**

4. Determine the sample standard deviation, s.

   Answer: $\text{s} = \sqrt{29.40092\ \text{cm}^2}$ = **5.42 cm**

Figure 6. Example Calculation Problem

Course management utilities are available to Professors on the Manage Tab (see Figure 7). These include viewing tables of student quiz and homework grades, displaying student activity for a particular exercise, changing chapter order and due dates, and controlling student access.

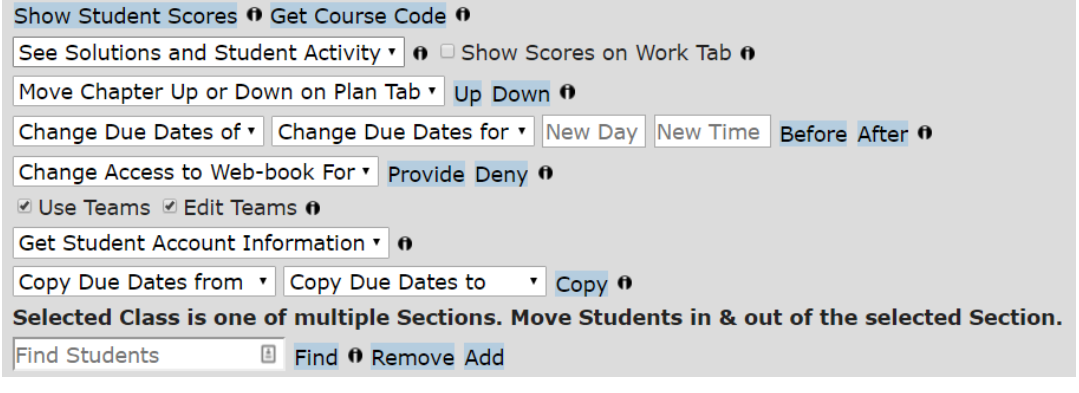


Figure 7. Course Management Utilities

Introductory Engineering Web-books

PathFinder web-books have been used since 2006 in courses in a college of engineering at a public four-year university in the northeast and, more recently, at a nearby community college. Two studies have shown the web-books to be effective. Everett, J. [1] demonstrated that PathFinder on-line calculation exercises were as effective as traditional homework, measured by student performance on exams. Everett et al. [2] demonstrated the effectiveness of PathFinder practice exercises. Research continues, with current work focusing on how students navigate

PathFinder to complete BEFORE exercises and the characteristics of difficult on-line multiple-choice problems. Significant content has been added to the PathFinder database since the publication of the two articles cited above. Content and web-book management utilities have also been improved. It is now possible for PathFinder web-books to be used outside the host institution. Given recent interest in affordable web-books, faculty at many institutions may be interested in using PathFinder or creating similar web-sites.

PathFinder currently provides affordable web-books for three introductory, multidisciplinary engineering courses, taught in over 50 sections a year. The courses are in the first, second, and third semesters of eight-semester engineering BS degrees. Students pay $30 for all three web-books, which they can access for their entire college experience and beyond. Students can also save chapters to pdfs. The web-books contain 34 PathFinder chapters (Figure 8), containing over 189,000 word-equivalents (tables and figures counted as 300 words each) and 1,350 exercises.

Academic Success
Introduction to Engineering
Engineering Problem Solving
Engineering Communication (3 chapters)
Significant Figures
Uncertainty
Engineering Graphics
Statistics (2 chapters)
Engineering Economics (2 chapters)
MATLAB
Excel
Product Design
Intellectual Property
Engineering Ethics
Sustainable Engineering

General Engineering Design (3 chapters)
Universal Design
Design for the other 90 %

Engineering Fundamentals:
Length, Time, Mass, Force, Heat, Electricity, Power
(7 chapters)

Environmental Issues:
Anthropocentric Global Warming, Nonrewable Resource Depletion, Stratospheric Ozone Depletion, Photochemical Smog, Acidification, Ecological Harm
(3 chapters)

Figure 8. Chapters available in PathFinder for Introduction to Engineering Courses

A Platform for Affordable Web-books – Where to Go From Here?

The authors' University established an Affordability Task Force in 2016. The 'ProfCents' webpage describes resources for financially struggling students (https://sites.rowan.edu/student-success/profcents/). University support, beyond typical scholarships, includes: financial planning, coupons, an on-campus food pantry and resource center, wellness counseling, and free legal counsel. The Affordability Task Force has started a Textbook Alternative Program (TAP) to encourage lower cost course materials. PathFinder is an alternative textbook.

The authors want to leverage PathFinder to provide affordable web-books to students at interested institutions across the US. Professors can select, rearrange, and modify existing chapters (Figure 8) to create introductory engineering web-books customized for courses at any institution. As needed, professors can create additional articles and chapters.

The authors intend to use the FYEE forum to discuss the following with interested professors:

- What affordable text-books have professors used?
- Are professors interested in using web-books? What is an acceptable price range for affordable web-books?
- Is PathFinder an acceptable platform for web-books? What information do potential adopters need? Does it need modification? What alternatives exist?
- Is the PathFinder content described in Figure 8 sufficient for introductory engineering courses? Are additional articles and chapters needed? Are the content creation utilities in PathFinder sufficient?
- Are the PathFinder course management utilities sufficient for professors?

PathFinder is a web-book platform successfully used to disseminate affordable web-books to students at a four-year university in the northeast and a nearby community college. Current work includes expanding the platform to additional institutions. Participants at the FYEE conference will be provided the opportunity to discuss PathFinder (or alternatives) in particular and affordable textbooks in general.

References

[1] J. Everett "Cooperatively created on-line textbooks with randomly generated assignments", *Journal of Online Engineering Education*, vol. 1, pp. 10-19, 2010.

[2] J. Everett, K. Mallouk, J. Morgan, J. Stanzione ("Online Practice Problem Strategies" Journal of Online Engineering Education, vol. 5, pp. 1-9, 2014.