

Designing and Developing an Online Math Course – Creating a Student-Centered Model

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Abstract

The key to any course development, either tradition, hybrid or online is to ensure that students should benefit from the design. Online course development is no exception from that. This paper discusses some of the strategies that the author used in online math course development and taught. This article discusses various features in the design and development including course content, web design, student engagement, student support and teacher's presence. The author provides a critical review of the course design that help student to be motivated and learn in a student-centered environment. Recommendations for online course development are outlined.

Keywords: Online Math, course design, student engagement, communication, discussion, Instructor presence.

Introduction

Higher education is certainly shifting into a new paradigm. One of the key changes is providing online degree programs. In fact, many institutions have started to provide online degree programs for many disciplines. For many students, online degree program have always been a better option due to their work, family and for any other reason that they cannot attend classes in person. The pandemic that started in early 2020 made it a necessary to move classes to a remote setting. With the asynchronous and synchronous model in remote learning, institutions have started to investigate online course model with a new perspective. Harrison and Bergen (2000) noted that students must be self-motivated and independent learners to be successful in online programs. Twenty years later, as much as this statement is true, online course design, delivery methods, faculty involvement, and student support has an important role that could make it easier for students to be motivated and be better learners. This article focuses on general strategies that could be beneficial in creating a successful student-centered model for online courses. Higher education is now facing a major paradigm shift that will change traditional teaching and learning to new mode of learning and educators are required to keep up with these new changes.

Developing and teaching online courses is a unique experience from the traditional method of teaching and learning. The idea for this paper originated after designing and developing six online math courses, worked hours on redesigning online remedial math courses and had taught several online courses for the past five years. Online teaching has become a standard method in today's teaching environment (Wyk, 2019). Online courses have become one of the vital forms of course delivery in higher education in recent years. It is becoming necessary for the higher education institutions to provide online courses to keep

their place in the competition. At this moment in higher education, educators are required to teach and create courses that informs, educates, and motivates the learners to complete the course successfully (Wyk, 2019). This paper address some of the strategies that higher education educators should consider in designing and developing a student-centered online math course.

Getting ready to develop your online math course

Durak and Ataizi, 2016 noted that the recent developments regarding online learning helps to meet the educational needs of modern society and has increased the demands for online learning. The NMC Horizon report published in 2018 noted that learners of this technology era, like to access information as quickly as possible and as needed. The report noted that learners want to access resources easily and prefer immediate feedback. Durak and Ataizi, (2016) mentioned that students are hoping to continue the education that aligns with the developing technology and not content with traditional methods of teaching and learning.

Before starting the development, identify the course that is offered online and when it will be offered. If the course has a prerequisite course, consider working on that as well but it is not necessary. Including the available technological tools that aligns with math courses would be an added advantage in developing a student-centered model. A research on the available course products would help to enhance the course. If the course is delivered through Learning Management System (LMS) used by the institution, preparing and getting training on the LMS is beneficial. Harrison and Bergen (2000) recommended that faculty receive training in both course management and delivery system used in the institution and the authors recommended that faculty get training in the techniques of designing an effective online course.

What to consider when developing an online math course

Martin et.al (2019) noted that online instructors considered using a systematic design process, backward design where the students learn the material and then answer questions get help, as they need them. Faculty considered learner needs and focused on learner interaction during the design process. Teaching in the online format requires more structure and the instructor should organize better than in the regular classroom. (Harrison & Bergen, 2000). The above statements cannot be overstated. Students mostly learn on their own in an online course. The instructor is present to help them with any questions, but any online course is the opposite of a traditional face-to-face class environment. How do we address the main components in developing and teaching an online math course that could provide an environment to learn seamlessly? Following are some of the topics considered in developing online math courses:

- Relevant content
- Web design
- Student engagement
- Communication
- Student support

Relevant course content

As in traditional courses, online courses require a syllabus that aligns with the outcomes of the learning. Before starting to work on the course material, having the topics ready and what goes in each week would show the bigger picture. If faculty plan to add an adaptive courseware in the online courses like ALEKS, MyMathLab, Hawkes etc., it is advisable to understand and get the necessary training in these courseware. As much as the courseware will reduce the burden of both faculty and the designer, not so carefully picked topics can create chaos in learning.

Lachen and Chen (2019) noted that by using ALEKS courseware in their College Algebra course, students' knowledge on the targeted topics improved by 53% with a 6% standard deviation. The authors further noted that the hardest topics such as "Polynomial and Rational functions" and "Exponential and logarithmic functions" improved by 78% and 90% respectively. Oxman and Wong (2014) mentioned that adaptive learning dynamically adjusts to students' abilities both in level and instructional methods. Adaptive learning has at least three components a content model, a learner model and an instructional model as suggested by Oxman and Wong (2014) in their white paper: Adaptive Learning Systems. Whether the decision is to add an adaptive courseware or not, a clear objective and learning outcomes that aligns with the course is necessary.

Adding instructor created materials on the weekly modules with examples, videos gives a personal touch from the instructors and an extra resource in learning. A master course with the instructor-developed material is good enough to copy to individual courses. Durak and Ataizi (2016) mentioned that they used the same content in both traditional and online courses but increased the digital sources and transformed some of the current lesson notes into digital format. Collaborating with web designers from the stat could be helpful to design the course as per the faculty vision for the course.

Week 2 - Overview	✓
Section 11.1	✓
The Cartesian Coordinates in Three Dimensions	✓
11.1 Three-Dimensional Cartesian Space Jan 24 10 pts	✓
Section 11.2	✓
Vector Terminology and Notation	✓
Vector Algebra	✓
Section 11.3	✓
The Dot Product and its Properties	✓
Applications of the Dot Product	✓
11.3 The Dot Product Jan 24 10 pts	✓
Week 2 - Collaboration Space 5 pts	⊘
Week 2 - Quiz 1 Submission Area Jan 24 30 pts	✓

Figure 1: Weekly module

In creating the course content, the following could provide some guidelines:

- Plan ahead and have a complete lesson plan before you start
- Instructors are not creating a textbook, so keep the material concise
- Content should be precise and align with the learning outcomes
- Providing couple of examples of relevant topics is helpful
- Weekly assignments, quizzes, discussions keeps students on track
- Instructor created videos connect students with real people
 - Create videos that are natural and simple
 - Create videos for the examples in the course content
 - Short and separate video for each chosen example
 - Adding the pdf of the written work for the video examples for reference

My Media

Media Gallery

Incomplete Form

Rubrics

Early Alert

Attendance Reporting

UDOIT

Folio

Smartinking Online Tutoring

Collaborations

Pages

Files

Outcomes


Settings

Example:

Solve the initial value problems:

$$\frac{dy}{dx} = x - 2; y(1) = 3$$

Watch the following video to see the step-by-step process of solving the above problem:



The video player shows a red 'M' logo with a play button in the center. Below the logo, the text 'YVILLE UNIVERSITY' is visible. The video player interface includes a progress bar at the bottom showing 0:00 / 2:28, a volume icon, a 1x zoom icon, and a red 'M' logo in the bottom right corner.

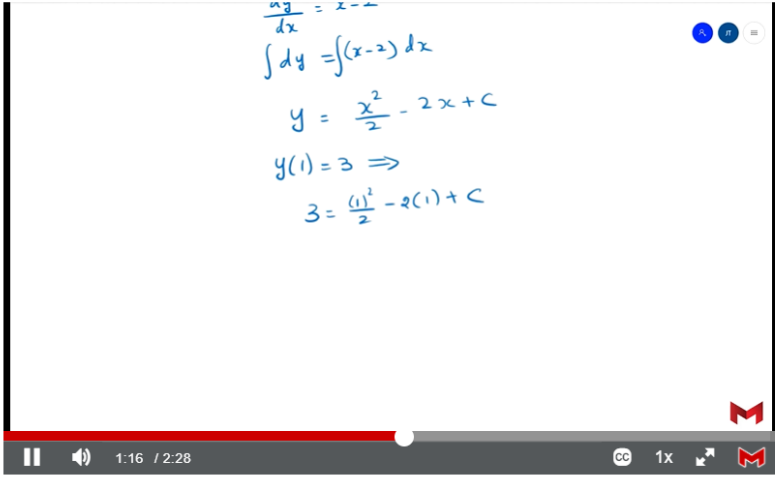
Figure 2: Video of an example created by the instructor

Example:

Solve the initial value problems:

$$\frac{dy}{dx} = x - 2; y(1) = 3$$

Watch the following video to see the step-by-step process of solving the above problem:



The video player shows handwritten mathematical work on a white background. The work includes the following steps:

$$\frac{dy}{dx} = x - 2$$

$$\int dy = \int (x - 2) dx$$

$$y = \frac{x^2}{2} - 2x + C$$

$$y(1) = 3 \Rightarrow$$

$$3 = \frac{(1)^2}{2} - 2(1) + C$$

The video player interface includes a progress bar at the bottom showing 1:16 / 2:28, a volume icon, a CC icon, a 1x zoom icon, and a red 'M' logo in the bottom right corner.

Figure 3: Video of a worked example created by the instructor

Harrison and Bergen (2000) noted that providing an outline of the course, any prerequisite required for the class, objectives, textbooks are important. Providing information on how tests will be administered, weights of different categories should be provided as in traditional courses. It would also be efficient if the faculty could add the technical resources, peer tutoring, and student support information to the modules. This will reduce the time to respond to student queries.

Harrison and Bergen (2000) noted that developing any successful online course is an ongoing process. As instructors gain experience in online teaching and learn about available technology, they should explore ways to present the content, use high quality audio, video techniques and software. Apart from this, checking for updates, added websites and link every few semester will keep the course up to date. Review at each stage of development could be useful to correct any errors or pause to see if any improvement is necessary.

Assignments are weighted by group:	
Group	Weight
Course Basics	2%
Prerequisite Review	3%
Hawkes Learning Topics	30%
Discussions	0%
Quiz Submission Area	20%
Tests	20%
Review	0%
Final Exam	25%
Hawkes	0%
Total	100%

Figure 4: Weighted assignment example

Important Instructions Before you Begin

Step 1: Select your Hawkes Learning quiz, test, or exam assigned for this section/module through the single sign-on in the [redacted] of this course.

Step 2: Complete your [redacted] quiz, test, or exam showing all written work.

Step 3: Submit a copy of your written work to the assignment link below:

Once you have completed this week's quiz, test, or exam in Hawkes, you will need to submit a copy your written work that shows how you have worked the problems, to this assignment link in Canvas. To do this, you need to:

- Scan or take a picture of your work with a digital camera, cell phone camera, or scanner. The pictures you take should be clear and readable.
- Copy these pictures into a single collated Microsoft Word document or PDF file.
- Save the file with your name and the respective assignment number
 - Example: - Smith_Quiz1
- Upload your single collated file (containing all of your written work) to this the quiz submission area in Canvas.
- Go back to the assignments area and double-check whether your file is properly uploaded in Canvas and can be opened and viewed without an issue.
- You can upload your work from notability as well

Figure 5: Directions for taking Quiz, Test

Kellar (2016) created a motivation strategy design for learning. Kellar’s Attention, Relevance, Confidence, Satisfaction and Volition (ARCS – V) model could act as a foundation in creating the course design and content.

Categories	Instructor's Self-Analysis	Instructor 's Analysis of Learners
Attention	Am I excited about this learning experience and how I can make it interesting?	Are the learners going to be interested? What tactics will stimulate their curiosity and interest?
Relevance	Do I believe that this learning experience will be valuable for my learners?	Will learners believe it is valuable? What can I do to help them believe it is important?
Confidence	Am I confident in my ability to lead this learning experience effectively and interestingly?	Will the learners feel confident about their ability to learn this? What do I do to help them be confident?
Satisfaction	Do I expect to have positive feelings about this learning experience?	What can I do to help the learners feel good about their experience and desire to continue learning?
Volition	Will I provide effective supervision and support to the learners throughout this learning event?	What can I do to help the learners maintain their goal orientation and task-focus throughout this learning event?

Table 1. Kellar’s (2016) ARCS–V model

Web design

As the faculty are preparing for your first online course development it may look similar to the traditional course delivery (Harrison & Bergen, 2000). As the online programs grow, the online student's community is not a subset of the traditional program anymore. The need of this community is different from traditional face-to-face students. With the development of technology, added features in the course, like videos, apps like zoom for office hours, jamboard, LiveBoard for collaboration could lead to active learning in the online program. It is worth the time to include your web designer from the beginning of the course development to design the course and use the available technology to create a student-centered model. An interactive web design could be help for students. Durak and Ataizi (2016) included communication factors that allow learners to interact with each other, with the faculty through forums, emails, chat modules. A clever web design in the online courses could use the following:

- Student friendly web design
- Easy to navigate
- Accessible to everyone
- Organized well
 - Modules that includes weekly contents
 - Assignments from weekly topics
 - Quiz from the weekly learned material
 - Interactive problems to practice in-between learning

Online courses should be accessible to everyone as per the standards provided by the education department. Reviewing the policies and procedures and getting training on accessibility is important.













⋮		11.1 Three-Dimensional Cartesian Space Week 2 Module Closed Due Jan 24 at 11:59pm 10 pts	✓
⋮		11.2 Vectors and Vector Algebra Closed Due Jan 24 at 11:59pm 10 pts	✓
⋮		11.3 The Dot Product Week 2 Module Closed Due Jan 24 at 11:59pm 10 pts	✓
⋮		11.4 The Cross Product Week 3 Module Available until Jan 31 at 11:59pm Due Jan 31 at 11:59pm 10 pts	✓
⋮		11.5 Describing Lines and Planes Week 3 Module Available until Jan 31 at 11:59pm Due Jan 31 at 11:59pm 10 pts	✓
⋮		12.1 Vector-Valued Functions Week 4 Module Not available until Jan 31 at 12:00am Due Feb 7 at 11:59pm 10 pts	✓
⋮		12.2 Arc Length and Unit Tangent Vector Week 4 Module Not available until Jan 31 at 12:00am Due Feb 7 at 11:59pm 10 pts	✓
⋮		13.1 Functions of Several Variables Week 5 Module Not available until Feb 7 at 12:00am Due Feb 14 at 11:59pm 10 pts	✓
⋮		13.2 Limits and Continuity of Multivariable Functions Week 5 Module Not available until Feb 7 at 12:00am Due Feb 14 at 11:59pm 10 pts	✓
⋮		13.3 Partial Derivatives Week 6 Module Not available until Feb 14 at 12:00am Due Feb 21 at 11:59pm 10 pts	✓
⋮		13.4 The Chain Rule Week 7 Module Not available until Feb 21 at 12:00am Due Feb 28 at 11:59pm 10 pts	✓
⋮		13.5 Directional Derivatives and Gradient Vectors Week 8 Module Not available until Feb 28 at 12:00am Due Mar 7 at 11:59pm 10 pts	✓

Figure 6: Organized content, Assignments

Student Engagement

Redmond et.al (2018) noted student engagement as an important benchmark and quality indicator of student experience in higher education online learning. The authors acknowledged as the institutions are shifting to online learning environment, adjustments to teaching and learning practices are required than that is associated with the university learning environment. Redmond et.al created a framework for online engagement for higher education students and it consists of five major components: Social, Cognitive, Behavioral, Collaborative, and Emotional.

Online Engagement Element	Indicators (Examples)
Social Engagement	Building community Creating a sense of belonging Developing relationships Establishing trust
Cognitive Engagement	Thinking critically Activating metacognition Integrating ideas Justifying decisions Developing deep discipline understandings Distributing expertise
Behavioral Engagement	Developing academic skills Identifying opportunities and challenges Developing multidisciplinary skills Developing agency Upholding online learning norms Supporting and encouraging peers
Collaborative Engagement	Learning with peers Relating to faculty members Connecting to institutional opportunities Developing professional networks
Emotional Engagement	Managing expectations Articulating assumptions Recognizing motivations Committing to learning

Table 2. Online Engagement Framework for Higher Education

Student engagement can start from the very beginning of the class. A welcome message from the instructor could be a right place to create a social environment. In our courses, we ask the students to introduce themselves within the first three days of the start of the course under the title: Introduce yourself and have the following prompt:

Please take a moment to introduce yourself to your peers in this course. Share your answers for the following questions:

1. Name
2. Major
3. Last math class taken and how recently

4. Opinion of math on a scale of 1 to 5, where 5 = Love it, 3 = It's okay, and 1 = I'd rather have a root canal
5. An interesting fact about me is...

We encourage students to return to the discussion, read their classmates postings and respond.

Letting the students know that they can any fears in taking this course, and that we are all in this together could ease some anxiety.

The above questions and encouragement break the ice in our courses and the instructors provide a low stake of five points for this assignment. Announcement page can be used to post any announcements you would like to share with your students.

Discussion boards are another place to engage students cognitively. Posting a real-world problem related the current weekly topics would help students to think critically and engage them in a conversation. Harrison and Bergen (2000) noted that there are variety of ways to organize the discussion folders: chapter wise, weekly discussion questions, assignment wise. A brief note on the LMS and syllabus can help the students to understand the expected behavior in writing the discussion posts. Discussion board helps students to share ideas and support each other. Emotional engagement comes with time and taking online courses regularly. However, faculty can help by providing the syllabus, course outline with assignment due dates, assessment measures and course expectations. Harrison and Bergen (2000) noted a simple reminder about the assignment due date to the students could be helpful. Project-based learning is another way to collaborate and engage students in the course and with each other.

Instructor Presence/ Communication

Ekmekci (2013) suggested that the instructors involved in asynchronous online learning should pay special attention to let the learners know of their presence and argued that strong teaching presence is a critical component in online courses. The author noted that recorded material, mass emails, posting comments cannot be a way to reach students. Ekmekci (2013) suggested that a systematic approach of giving both formative and summative assessments, classroom assessment techniques are important to consider. However, Richardson et.al (2015) noted that an aspect of instructor presence is immediacy. The authors mentioned that instructor presence related to how the instructors position themselves socially and pedagogically in an online community. Their research concluded that students might have a different perception of an instructor who does not share much information about them compared to another instructor who share more information that is personal.

Nevertheless, having an introduction page in your LMS course will be helpful to know the instructor as a person. Giving feedback on assignments and quizzes is another way to communicate with the students. Audio and video feedback are equally agreeable. Martin et.al (2019) concluded that award-winning faculty used timely response and feedback, availability and presence, and periodic communication as some facilitation strategies. Announcements are a great place to let students know about the upcoming assignments or any general announcement that the instructor like to share. LiveBoard, an app could be

used to answer questions to the students. Having a regular weekly online office hour(s) via zoom, skype could be beneficial for students to ask questions and a way to communicate with the instructor.

<p>Final Grades</p> <p>All Sections</p> <p>Dear students, I have graded your final exam. Do check the grades on your quiz, exam to see if anything...</p>
<p>Final Exam</p> <p>All Sections</p> <p>Dear Students, As you are preparing for the final exam, note that it is a comprehensive exam. The exam ...</p>
<p>Check your grades</p> <p>All Sections</p> <p>Dear students, Please check your grades and let me know if you see any error or any grade missing befo...</p>
<p>Week 14 grading, week 15 topics</p> <p>All Sections</p> <p>Dear Students, I have graded week 14 . Check the feedback. For week 15: Complete 15.3, 15.4. There i...</p>
<p>week 13 grading and week 14 topics</p> <p>All Sections</p> <p>Dear Students, I have graded week 13 . Check the feedback. For week 14: Complete 15.1, 15.2 and Qu...</p>
<p>week 12 grading and week 13 topics</p> <p>All Sections</p> <p>Dear Students, I have graded week 12 . Check the feedback. Review the topics again if you have not s...</p>
<p>Week 11 grading, week 12 topics and Test 3</p> <p>All Sections</p>

Figure 7: Using announcement page for communication

Student Support

Lee et.al (2011) found that perceived support for the students from the institutions is directly related to the overall student satisfaction on an online course. The study suggested that instructors should clearly communicate the available resources and provide an easy way of accessing the resources. Student support should include both academic support and Institution provided support. From the academic perspectives, analyzing weekly reports of the students through adaptive courseware or other assessment measures would help to find the gaps in student learnings, difficult topics and ways to address them. Most of the time, an early alert and timely intervention could help the student to get back on track.

Providing timely feedback and clear communication would help students to understand what went wrong and how to rectify it. Online office hours could be a major academic support from the instructors. Hart (2012) noted that technical support consists of any assistance related to computer and technology. Providing the list of available technical resources along with the contact list to the students through LMS

could give an easy access for technical support. Many institutions provides tutoring services for their students. Making students aware of these programs is essential. Fahy (2003) noted that technology-based, peer-to-peer interaction might constitute a valuable form of support. The author’s study concluded that the participants used interpersonal strategies to support each other through open-ended questions, referred to each other’s contents on the comments, invited others to join the conversation and used emoticons to clarify their tone.

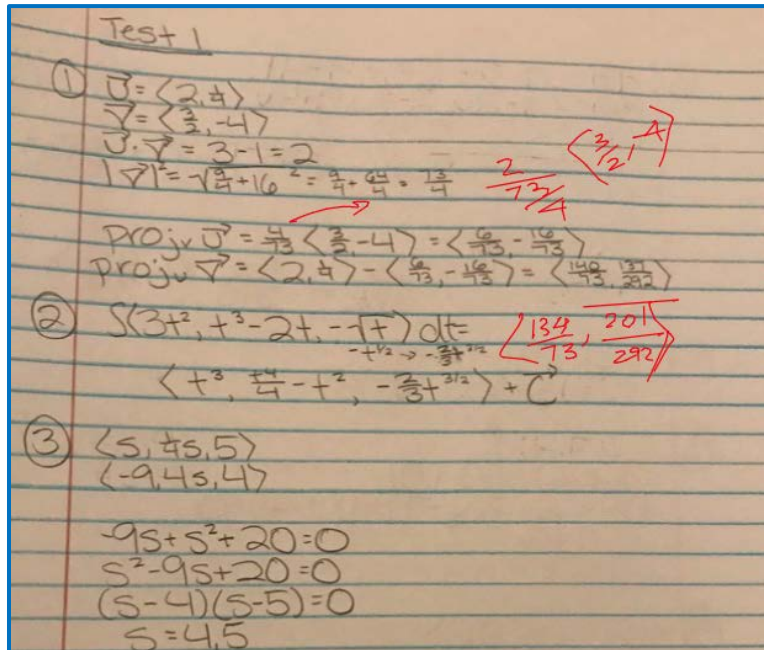


Figure 8: Instructor feedback

Conclusion

As online courses are becoming mainstream in higher education learning, faculty and the institutions are obligated to provide the best they can to their students who choose to be in online environment. The commitment to the online course development does not end after delivering the course. It is an ongoing process as the technology continues to improve. Khan et.al (2017) noted that both faculty and students preferred consistency in the course design. Students were content when they come across courses with similar design as the navigation through the courses became easier. As cited by the authors

“Some best practices for online course development include using integrative course design with measurable learning outcomes, presenting information in a variety of ways, breaking information into appropriate segments, clarifying expectations, promoting active learning, and the effective use of discussions” (Resources for Online and Hybrid Teaching - Center for Engaged Instruction, 2012).

Creating an online course is not only about the content, resource and delivery method. It is also about creating an online community and keeping it live. Being supportive encourages students to participate more. Making resources available and the faculty presence are essential in an online course. Checking the course content, every couple of semester for any broken links or updates is mandatory. The focus of this

paper is about developing an online math course; however, the ideas would work for any online course design in the higher education settings.

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