AC 2007-454: ONLINE TEACHING OF ELECTRICAL POWER SYSTEMS IN ELECTRICAL ENGINEERING; EXPERIENCES AND MYTHS

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Online Teaching of Mathematics in Electrical Engineering; Experiences and Myths

Abstract- Online teaching is here to stay. Because of different learning styles we must be extra careful with the integration of technology into teaching. We can not longer deny or refuse to teach online, therefore we must reinvent ourselves and develop skills that we did not have or did have and did not know it. This paper attempts to describe the experiences we have had in the teaching of electrical engineering courses online. More specifically, how we deal with mathematics and its delivery online. We will show how effective the system that we implemented has been for the teaching of mathematics online. We will compare online teaching versus the classical classroom teaching. To do so we split one class in two sections; the first one is the online section and the second one is the classroom section. To reduce duplication, while the online section is taking the class, we had an LCD projector with the computer screen on it for the classroom section.

Discussion-Higher education is making the change from classroom education to online education. The enrollment of online education keeps going up at a very fast rate in the United States. In 2004 [1] about 2.3 million students where enrolled in online courses. Universities have been developing strategic plans to tackle the implementation of online teaching. The major hurdles needed to overcome are; *changing the mindset of faculty*, budgets, teacher training in *new technologies*, online student population's *new studying habits* and *quality of instruction.*

Change

Change is never easy; perhaps it is the most difficult hurdle in online teaching. Faculty, need to be fully aware of the linking of *pedagogy, technology and learning-styles* [2]. Furthermore, it has been our experience that the need of "electronic textbooks" is the critical event that will facilitate online teaching of electrical engineering in a very large scale. (Which by the way, it is happening very fast)

Budget

Online teaching is expensive. Simply put: the technology used costs large sums of money. Only the software and hardware used to deliver lectures absorbs a large percentage of the budget. For example, we use Webct , Elluminate, in the software area; LCD projectors, Smart boards, Tablet personal computers and smart classrooms in the hardware area.

Training

Many of the faculty teaching online had to be retrained and supported by technicians. This, also, costs money and time.

Students

As mentioned before change is not easy and online students have to change their studying habits and personal time planning. One major change is the ability to self study. We would assume that college students would have such skill, but we are finding out that that is no the case.

Quality of instruction

Quality of instruction is a big problem. Not everybody can do well taking an online course, therefore, this issue becomes an assessment issue. The monitoring of quality instruction and its effectiveness is still in progress and there is no a definite answer available. A common assessment is student achievement and satisfaction, but it is not enough to arrive to a conclusive result.

Finally the big question becomes; *where is online teaching going*? *Why online teaching*? The answers will be attempted on this paper.

Online Mathematics in EE-The previous discussion was created to set up the scenario of what we have done in the past two semesters. In this section we will indicate the implementation of an online graduate level course in Electrical Engineering. This course has been taught for several years in the face-to face (classroom) mode and it has had the usual outcomes of such way of teaching. However, online teaching created a challenge of great magnitude at the logistical and instructional level.

We used “Elluminate” as well as “Smartboard” as our technology medium. This system was effective but only to certain degree. For example, since we did not have our lectures prepared in “power point format” and did not have an electronic version of the textbook, we needed to scan our lecture notes. That was a major time consuming issue. The advantage of Elluminate over Webct was the ability of having sound, video and pc screen via internet. In combination with smartboard, it made the delivery of the material quite easy compared to Elluminate alone.

The delivery of mathematics using this system created a challenge. We first used our scanned notes to do so and it became very clear that the level of detail in the explanation and discussion achieved in the face-to-face mode was not achieved in the online mode. We had to adjust and do the best we could. The major change was the delivery of the material in a mostly verbal mode. Another change was the presentation of the major highlights of the discussion and the consistent questioning of the faculty trying to get some real time feedback from students.

Since our goal is to engage our students and create the environment for deep learning of mathematics applied to electrical engineering, we came up with a “funnel” approach. Figure 1 shows what we consider the way we must engage [3] students into deep learning. Keeping that in mind, we started to create our own online model for this class.

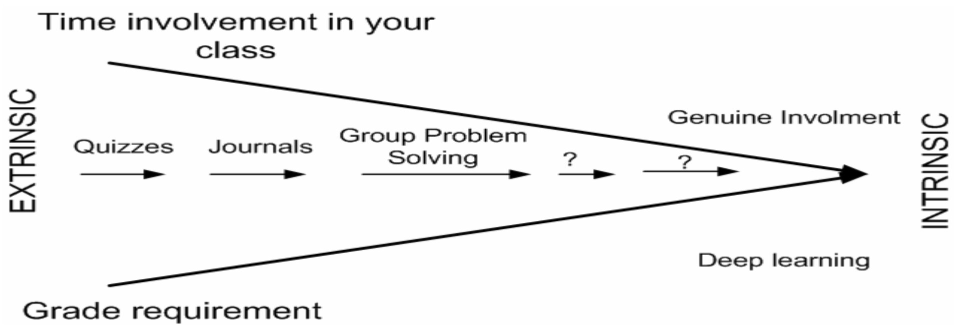

Figure 1 Student Engagement

Soon into the semester, it was obvious that a change was needed to deliver the mathematical content of the course more effectively. It was decided to require the use of Matlab in all assignments also it was used as a tool to explain mathematical concepts. Figure 2 shows an example of a Matlab assignment and the student's report. While this method worked for a while, there were some issues with the access of Matlab. Students had to buy their on version since they could not get to campus to use the University computers. Power World is other software that we have been using sporadically. Since the student version is free, the access to it was not a problem

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<u>Summary</u>

1. <u>Gauss Iteration</u>

   $V_2 = 0.9330 - j0.25 = 0.9659<-15^{\circ}$

   $S_{12} = -0.50 – j0.1340$

2. <u>Newton-Raphson (After Two Iterations)</u>

   $\theta_2 = -0.0524$ (radian)

   $|V_3| = 0.9502$

   $\theta_3 = -0.1744$ (radian)

   $S_G = 2.1980 + j0.1360$

   $Q_{G2} = 1.6389$

3. Fast Decoupled (After Two Iterations)

θ_2 = -0.0522 (radian)

$|V_3|$ = 0.9517

θ_3 = -0.1722 (radian)

4. Contingency Analysis (DC Power Flow Method)

ΔI_{12} = -j0.0687

Matlab1

```
Y=[-j*2  j*2;
   j*2 -j*2];
V1=1+j*0;
V2=1+j*0;

S2=-0.5;
iter=0;

for I=1:10;
iter=iter+1;
V2=(conj(S2)/conj(V2)-Y(2,1)*V1)/Y(2,2);
end

V2
V2_mag=abs(V2)
V2_ang=(angle(V2))*180/pi

I12=Y(1,2)*(V1-V2);
S12=V1*conj(I12)
```

Matlab2

```
% Final Problem 2 Newton-Raphson Method
V1 = 1;
theta_1 = 0;
V2 = 1.05;
P_G2 = 0.6661;
S_D3 = 2.8653 + j*1.2244;

Y = [-j*19.98  j*10     j*10;
```

```
      j*10    -j*19.98  j*10;
      j*10     j*10    -j*19.98];
B = imag(Y);

theta_2 = 0;
theta_3 = 0;
V3 = 1;

Estimate = [theta_2; theta_3; abs(V3)];

P2 = P_G2;
P3 = -real(S_D3);
Q3 = -imag(S_D3);

iter = 0;

for I=1:2
iter = iter + 1;

Mismatch_1 = P2 - (abs(V2)*abs(V1)*B(2,1)*sin(theta_2 - theta_1) + ...
                abs(V2)*abs(V3)*B(2,3)*sin(theta_2 - theta_3));
Mismatch_2 = P3 - (abs(V3)*abs(V1)*B(3,1)*sin(theta_3 - theta_1) + ...
                abs(V3)*abs(V2)*B(3,2)*sin(theta_3 - theta_2));
Mismatch_3 = Q3 - (-abs(V3)*abs(V1)*B(3,1)*cos(theta_3 - theta_1) - ...
                 abs(V3)*abs(V2)*B(3,2)*cos(theta_3 - theta_2) - ...
                 abs(V3)*abs(V3)*B(3,3));

Mismatch = [Mismatch_1; Mismatch_2; Mismatch_3];

J = zeros(3,3);

J(1,1) = abs(V2)*abs(V1)*B(2,1)*cos(theta_2 - theta_1) + ...
        abs(V2)*abs(V3)*B(2,3)*cos(theta_2 - theta_3);

J(1,2) = -abs(V2)*abs(V3)*B(2,3)*cos(theta_2 - theta_3);

J(1,3) = abs(V2)*B(2,3)*sin(theta_2 - theta_3);

J(2,1) = -abs(V3)*abs(V2)*B(3,2)*cos(theta_3 - theta_2);

J(2,2) = abs(V3)*abs(V1)*B(3,1)*cos(theta_3 - theta_1) + ...
        abs(V3)*abs(V2)*B(3,2)*cos(theta_3 - theta_2);

J(2,3) = abs(V1)*B(3,1)*sin(theta_3 - theta_1) + ...
        abs(V2)*B(3,2)*sin(theta_3 - theta_2);
```

```
J(3,1) = -abs(V3)*abs(V2)*B(3,2)*sin(theta_3 - theta_2);

J(3,2) = abs(V3)*abs(V1)*B(3,1)*sin(theta_3 - theta_1) + ...
        abs(V3)*abs(V2)*B(3,2)*sin(theta_3 - theta_2);

J(3,3) = -abs(V1)*B(3,1)*cos(theta_3 - theta_1) - ...
         abs(V2)*B(3,2)*cos(theta_3 - theta_2) - 2*abs(V3)*B(3,3);

J_inv = inv(J);
correction = J_inv*Mismatch;

Estimate = Estimate + correction;

theta_2 = Estimate(1);
theta_3 = Estimate(2);
V3 = Estimate(3);

end

theta_2
theta_3
V3

V = [V1; V2; V3];
d = [0; theta_2; theta_3];
t = angle(Y);
Y = abs(Y);

P1 = Y(1,1)*V(1)*V(1)*cos(t(1,1)) + Y(1,2)*V(1)*V(2)*cos(t(1,2)+d(2)-d(1)) + ...
     Y(1,3)*V(1)*V(3)*cos(t(1,3)+d(3)-d(1));
Q1 = -Y(1,1)*V(1)*V(1)*sin(t(1,1)) - Y(1,2)*V(1)*V(2)*sin(t(1,2)+d(2)-d(1)) - ...
      Y(1,3)*V(1)*V(3)*sin(t(1,3)+d(3)-d(1));

S_G = P1 + j*Q1

Q_G2 = -Y(2,1)*V(2)*V(1)*sin(t(2,1)+d(1)-d(2)) - Y(2,2)*V(2)*V(2)*sin(t(2,2)) - ...
       Y(2,3)*V(2)*V(3)*sin(t(2,3)+d(3)-d(2))
```

Matlab3

```
% Final Problem 3 Fast Decoupled Method
V1 = 1;
theta_1 = 0;
V2 = 1.05;
P_G2 = 0.6661;
```

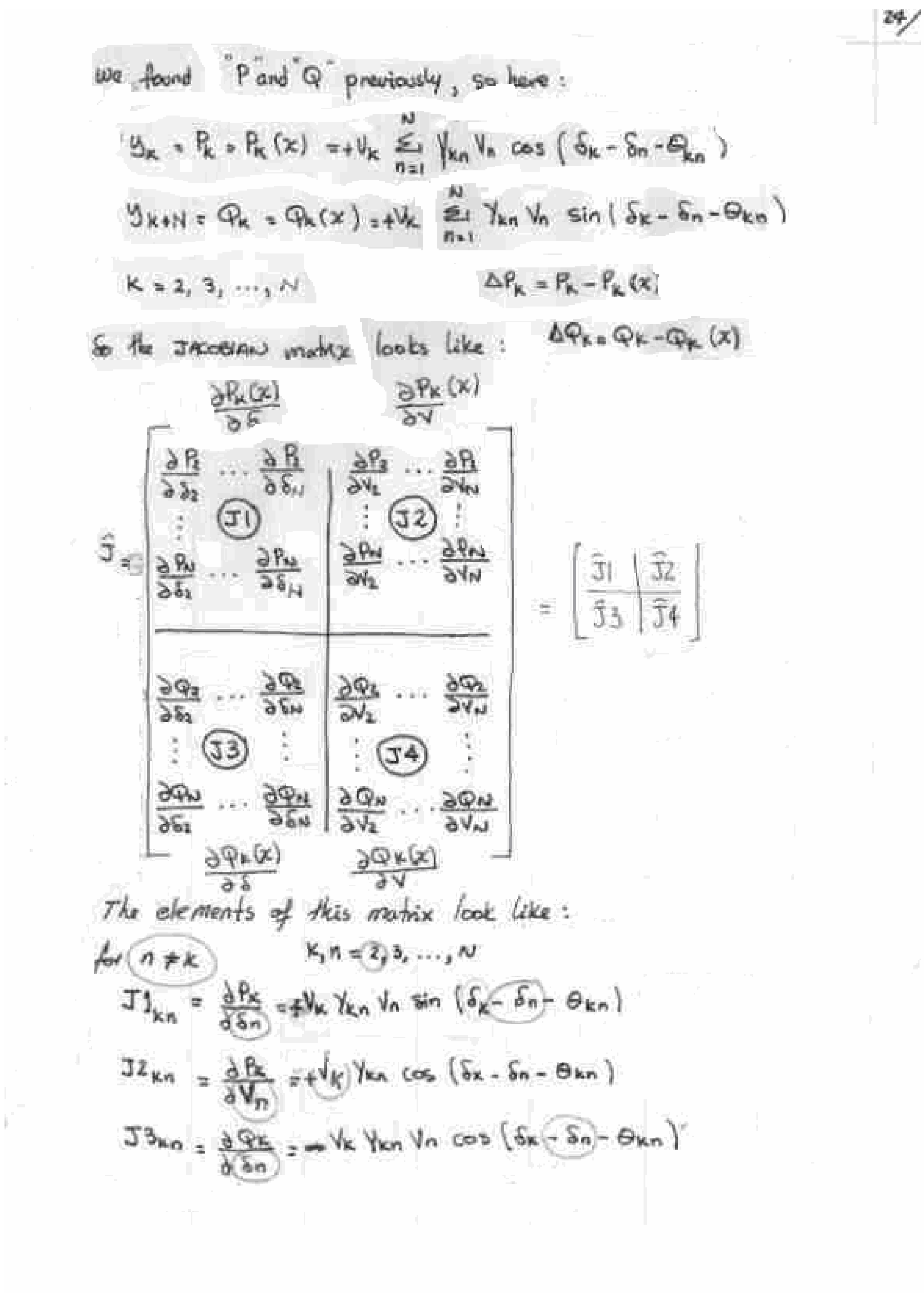
```
S_D3 = 2.8653 + j*1.2244;

Y = [-j*19.98  j*10     j*10;
     j*10    -j*19.98  j*10;
     j*10     j*10    -j*19.98];
B = imag(Y);

Bp = [B(1,1), B(1,2); B(2,1) B(2,2)];
Bp_inv = inv(Bp);

Bq = B(3,3);
Bq_inv = 1/Bq;

theta_2 = 0;
theta_3 = 0;
V3 = 1;

Estimate = [theta_2; theta_3; abs(V3)];

P2 = P_G2;
P3 = -real(S_D3);
Q3 = -imag(S_D3);

iter = 0;

for I=1:2

iter = iter + 1;

Mismatch_1 = (1/abs(V2)) * (P2 - (abs(V2)*abs(V1)*B(2,1)*sin(theta_2 - theta_1) + ...
                abs(V2)*abs(V3)*B(2,3)*sin(theta_2 - theta_3)));
Mismatch_2 = (1/abs(V3)) * (P3 - (abs(V3)*abs(V1)*B(3,1)*sin(theta_3 - theta_1) + ...
                abs(V3)*abs(V2)*B(3,2)*sin(theta_3 - theta_2)));
Mismatch_3 = (1/abs(V3)) * (Q3 - (-abs(V3)*abs(V1)*B(3,1)*cos(theta_3 - theta_1) - ...
                 abs(V3)*abs(V2)*B(3,2)*cos(theta_3 - theta_2) - ...
                 abs(V3)*abs(V3)*B(3,3)));

Mismatch = [Mismatch_1; Mismatch_2; Mismatch_3];
Mismatch_P = [Mismatch(1); Mismatch(2)];
Mismatch_Q = Mismatch(3);

delta_theta = -Bp_inv*Mismatch_P;
delta_V = -Bq_inv*Mismatch_Q;

delta = [delta_theta; delta_V];
```

```
Estimate = Estimate + delta;

theta_2 = Estimate(1);
theta_3 = Estimate(2);
V3 = Estimate(3);

end

theta_2
theta_3
V3
```

Matlab4

```
ECE612 Final Exam Problem #4

Y = [-j*6.25   j*5    0      j*1.25;

      j*5     -j*12  j*2     j*5;

      0        j*2  -j*4.5   j*2.5;

      j*1.25   j*5   j*2.5  -j*8.75];

Ybus = [Y(2,2) Y(2,3) Y(2,4);

        Y(3,2) Y(3,3) Y(3,4);

        Y(4,2) Y(4,3) Y(4,4)];

Zbus = inv(Ybus);

Z14 = 0;

Z24 = Zbus(1,3);

Zc = 0.2;

K12_4 = (Z14-Z24)/Zc;

Delta_I4 = 0.1;

Delta_I12 = K12_4*Delta_I4
```

Lecture Example-We posted the scanned lecture in our website at least four days in advance. Students had a chance to read it and print it on time for the lecture. Two very important observations came to light; one *that students did expect to see the material in advance* and two *that students would print the notes.* Here is an example of one of the scanned lecture notes.



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we found "P" and "Q" previously, so here:

$$y_K = P_K = P_K(x) = +V_K \sum_{n=1}^{N} Y_{Kn} V_n \cos(\delta_K - \delta_n - \theta_{Kn})$$

$$y_{K+N} = Q_K = Q_K(x) = +V_K \sum_{n=1}^{N} Y_{Kn} V_n \sin(\delta_K - \delta_n - \theta_{Kn})$$

$K = 2, 3, \ldots, N$ $\quad \Delta P_K = P_K - P_K(x)$

So the JACOBIAN matrix looks like: $\quad \Delta Q_K = Q_K - Q_K(x)$

$$\hat{J} = \left[\begin{array}{c|c} \overset{\frac{\partial P_K(x)}{\partial \delta}}{} & \overset{\frac{\partial P_K(x)}{\partial V}}{} \\ \begin{matrix} \frac{\partial P_2}{\partial \delta_2} & \cdots & \frac{\partial P_2}{\partial \delta_N} \\ \vdots & (J1) & \\ \frac{\partial P_N}{\partial \delta_2} & \cdots & \frac{\partial P_N}{\partial \delta_N} \end{matrix} & \begin{matrix} \frac{\partial P_2}{\partial V_2} & \cdots & \frac{\partial P_2}{\partial V_N} \\ \vdots & (J2) & \vdots \\ \frac{\partial P_N}{\partial V_2} & \cdots & \frac{\partial P_N}{\partial V_N} \end{matrix} \\ \hline \begin{matrix} \frac{\partial Q_2}{\partial \delta_2} & \cdots & \frac{\partial Q_2}{\partial \delta_N} \\ \vdots & (J3) & \vdots \\ \frac{\partial Q_N}{\partial \delta_2} & \cdots & \frac{\partial Q_N}{\partial \delta_N} \end{matrix} & \begin{matrix} \frac{\partial Q_2}{\partial V_2} & \cdots & \frac{\partial Q_2}{\partial V_N} \\ \vdots & (J4) & \vdots \\ \frac{\partial Q_N}{\partial V_2} & \cdots & \frac{\partial Q_N}{\partial V_N} \end{matrix} \\ \underset{\frac{\partial Q_K(x)}{\partial \delta}}{} & \underset{\frac{\partial Q_K(x)}{\partial V}}{} \end{array}\right] = \left[\begin{array}{c|c} \hat{J}1 & \hat{J}2 \\ \hline \hat{J}3 & \hat{J}4 \end{array}\right]$$

The elements of this matrix look like:

for $n \neq K$ $\quad K, n = 2, 3, \ldots, N$

$$J1_{Kn} = \frac{\partial P_K}{\partial \delta_n} = +V_K Y_{Kn} V_n \sin(\delta_K - \delta_n - \theta_{Kn})$$

$$J2_{Kn} = \frac{\partial P_K}{\partial V_n} = +V_K Y_{Kn} \cos(\delta_K - \delta_n - \theta_{Kn})$$

$$J3_{Kn} = \frac{\partial Q_K}{\partial \delta_n} = -V_K Y_{Kn} V_n \cos(\delta_K - \delta_n - \theta_{Kn})$$

Looking at this example we can understand why electronic textbooks are becoming necessary for online teaching. We did not have the time or the resources to type these notes. However handwritten notes were acceptable because Elluminate and Smartboard allowed us to write on top of the notes, consequently we have Image, Sound and Editing (ISE) all real time. Ideally you want to upload the power point images provided by most textbooks and then use ISE.

Expectations- Partlow and Gibbs [4] found that online courses should be relevant, interactive, project-based, and collaborative and should, furthermore, give learners some choice or control over their learning. Another study performed by Keeton [5] found out that instructional strategies that; promotes an environment, supports and encourages inquiry, broadens the experience of the subject matter and elicit active and critical reflection by learners is a reasonable expectation for teaching a class online or not. In our case most of the arguments given by [4] and [5] were accomplished. Simply put, we came to the realization that a project oriented course in engineering is not a bad idea, group work was mandated and encouraged and definitely we had a great level of interaction online. Data analysis was by default the most important aspect of the course because of the nature of the class.

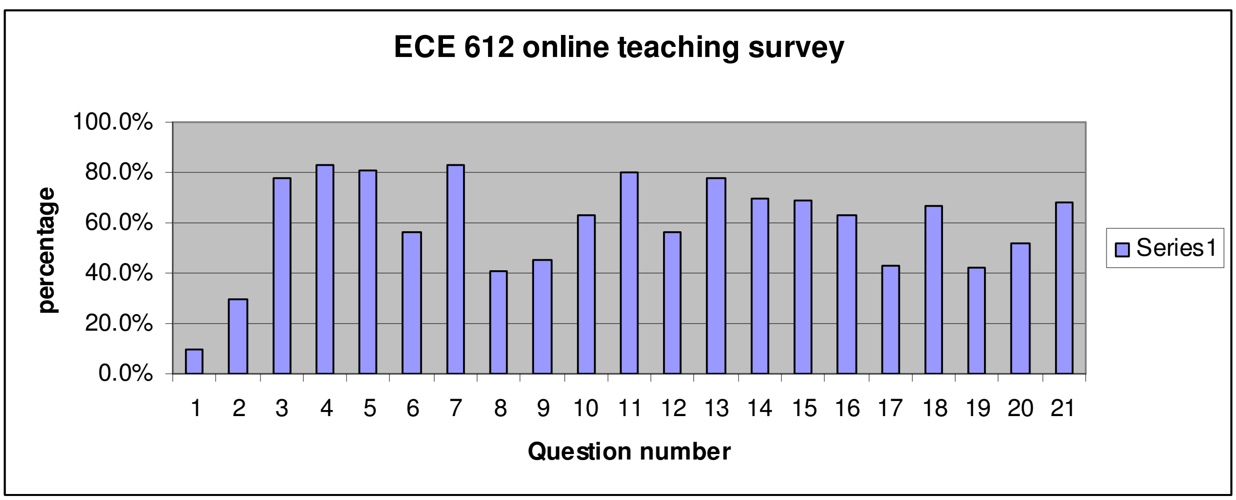
However, Bonk [6] found out in a survey that between 23 to 45 percent of online instructors used hands on experience, interactive labs, data analysis, and computer simulations.

Online teaching surveys [8]
Bonk and Kyong performed a survey in November of 2003 and obtained 562 responses. The survey was confined to the United States and had 10 questions. These are some fascinating results. For instance in the area of online success, 24.7% indicated that monetary support is top priority, and then it followed the technical competency of the online instructors with 22.9%. In the area of pedagogical techniques to be used more widely online in the coming decade, 65.4% indicated that group problem solving and collaborative task was at the top followed by problem based learning with 58.1%.

Class Survey- We performed a survey in class in order to obtain some feedback about online teaching mathematics. These are some findings;

Question Number	**question**	**Average**
1	Have you taken an online course before?	10%
2	Have you used the internet to study and analyze mathematics?	30%
3	Was the pace of the course adequate?	78%
4	Was the delivery of the material by the instructor clear?	83%
5	Was the communication between you and the instructor clear during the online session?	81%
6	Was the online course more convenient for you than the classroom lecture?	56%

7	Was the testing adequate?	83%
8	Did you feel that you spent more time studying with the online class than the regular classroom lecture format?	41%
9	Did you feel that you spent more time doing homework with the online class than the regular classroom lecture format?	45%
10	Did you feel that you spent more time solving quizzes with the online class than the regular classroom lecture format?	63%
11	Did you feel that your study habits had to change, adapt, for the online class?	80%
12	How much change, adjustment, you had to make in question 11?	56%
13	Material for the lecture was provided before the online class. Did it help you understand the lecture more?	78%
14	Lectures online were archived. Did it help you learn and understand more?	70%
15	Having instant access to the lectures and lecture notes online helped you learn more?	69%
16	Note taking was reduced greatly when online lecture was delivered. Did it helped you understand the material, learn, more?	63%
17	Did you feel that you were engaged into the material and the learning process more so than in the classroom setting?	43%
18	Was the mathematics of the course delivered adequately?	67%
19	Would you take another mathematically intensive online course?	42%
20	Would you recommend a mathematically intensive online course to a friend?	52%
21	What is your overall rating of an online course like this?	68%



Even though questions 4, 5, 7, 11, and 13 standout with about an average 80%, we feel that a great improvement needs to be made. Questions 18, 19, 20 and 21 apply to the overall course and the mathematics of it and the average was below 70%. This, in turn, indicates that our students, technology and instructor are not "linking" adequately.

Conclusions-Frustration was the common denominator in this online class. HOPE is the adjective that we have to have in order to succeed with online teaching. The premise that was used for years applies; not everyone is able or capable of taking an online course. The reasons; different learning styles, habits created for years in the classroom (change!), pace of the material, etc.

Students' ability of self learning and self discipline is a major factor for an online class. These issues will be resolved after a few classes taken online. Notice that only 10% of the students surveyed had taken an online class before.

Online instruction has become a myth and in all honesty smart classrooms with classroom instruction are the best solution. Online learning should be used only for circumstances where there is no alternative; otherwise we should remain in the classroom environment where body language, emphasis, eye contact make the difference.

Finally the survey given in class was performed with a small population sample, 10 students. The purpose for the survey was to obtain feedback and adapt for the next cycle of online teaching. As mentioned before there is no reliable assessment that can give conclusive results, but this fact does not mean that we should stop trying. Furthermore, online teaching is here to stay.

Bonk [8] created a survey with industry to find strategies for online learning. The table below shows the results. It is clear that almost a complete project oriented in combination with simulations could be the way to follow.

	Response Options	**Response Rate %**
1	Authentic cases and scenario learning	63.04
2	Simulations or gaming	50.00
3	Virtual team collaboration and problem solving	46.52
4	Problem-based learning	42.17
5	Coaching or mentoring	39.13
6	Guided learning	37.39
7	Self-paced learning	34.35

Instructional strategies to be more widely used in the coming decade

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