Linear Algebra BL class
with RPG and Mobile Sage

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“Korea's e-Campus Vision 2007” was a program begun in 2003. Most of lecture rooms at Sungkyunkwan University were equipped with beam projector, viewcam, tablet PC and internet database before 2006.

This provided a modern learning environment for our linear algebra classes. Computer demonstrations are easy, and lectures can easily be recorded so that students can review them right after class.

Today, we would like to share what we have experienced for teaching of Linear Algebra over the years in this new learning environment. It does include Java, Flash, random problem generator and Mobile Sage.

Key words: learning environment, e-Campus Vision, blended learning, Mobile Sage
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- Changes in educational environment
- New learning environment in Korea
- Blended learning - SKKU
- Various Tools – Java, Flash, RPG, Sage-Math
- Vision
- Conclusion
Changes in educational environment

Internet
The internet infrastructure has been widely spreading.

Students
connected and always can ask questions
Increase of demand on class information

Korea Education

Linear Algebra Education
Visualization and new tools

Learning Methods
Self-Directed Learning
Problem Based Learning
Blended Learning

Circumstance
Blended Learning Environments
I-Campus, E-Campus

Increasing the demand on the interactive contents
Changes in educational environment

Internet Environment for students

Naver KiN
(Knowledge Information System)

Wikipedia

Google Search Engine

Youtube
(UCC Multimedia contents)

DIGG

Napster

Myspace

Facebook

Craglist

Stationary point

In mathematics, particularly in calculus, a stationary point is a point in the domain of a function where the derivative is zero (equivalently, the gradient is zero), where the function "stops" increasing or decreasing (hence the name). For a function of one variable, this corresponds to a point on the graph where the tangent is parallel to the x-axis. For a function of two or more variables, this corresponds to a point on the graph where the tangent planes are parallel to the xy-plane.

The term is mostly used in one dimension, which this article discusses: stationary points in higher dimensions are usually referred to as critical points; see there for higher dimensional discussions.

Stationary point vs. critical point

The term "critical point" is often confused with "stationary point". Critical point is more general: a critical point is either a stationary point or a point where the derivative is not defined.

A stationary point is always a critical point, but a critical point is not always a stationary point. It might also be a non-differentiable point.

For a smooth function, these are interchangeable, hence the confusion; when a function is understood to be smooth, one can refer to stationary points as critical points. But when it may be non-differentiable, one should distinguish these terms.

Note that there is also a different definition of critical point in higher dimensions, where the derivative does not have full rank, but it is necessarily zero; this is analogous to stationary points, as the function may still be changing in some direction.

Classification

Isolated stationary points of a continuous real-valued function $f : \mathbb{R} \rightarrow \mathbb{R}$ are classified into four kinds, by the first derivative test:

- a minimal extremum (minimum turning point or relative minimum) is one where the derivative of the function changes from negative to positive;
- a maximal extremum (maximum turning point or relative maximum) is one where the derivative of the function changes from positive to negative;
- a rising point of inflection (or reflection) is one where the derivative of the function is positive on both sides of the stationary point, such a point marks a change in concavity;
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MIT—Linear Algebra (G. Strang) etc
Changes in educational environment

Internet Environment for students

- Naver KiN (Knowledge Information System)
- Wikipedia
- Google Search Engine
- Youtube (UCC Multimedia contents)
- DIGG
- Napster
- Myspace
- Facebook
- Craigslist
Report on the students activities of OECD countries.

Korean students are ready for ICT classes. They prefer to ask questions or answers over the internet. (Reply culture)
Changes in educational environment

Now, our students are living in a new learning environment!
What can we do for them? and Think what we have done!
All K-12 classroom was connected to internet by Jan. 2000. Same thing was done for college classroom before 2007. **We added our color on it in 2003.** Now all kinds of IT use for teaching in class are easy, and all of our activities (on tablet monitor) in the class can easily be recorded so students can review them right after class.

**It made Changes:**
Discussion on Math started back in our class!

**Blended learning**
Design a Blended learning class Model!
for new learning environment

1-week process
at SKKU Blended learning class

Multimedia Contents:
1) Java Applets
2) Flash Tools
3) Lecture Notes (PDF, PPT etc...)

In the next section, we will introduce all tools and multimedia contents.

Lecture note
First → Q&A – **Offline lecture** – HW- **Recorded lecture** – QnA – Discussion →
**Finalize all questions.** For all. → **Exams on all problems!!** (Better satisfaction!)
**New learning environment**
SKKU

http://vod.skku.ac.kr/studio/z_etc/e_lectureroom/index.html

"e-Campus Vision 2007" Project:

We designed e-Learning and Blended-Learning capable our own **e-lecture rooms** that meet the most of the required DOE criteria.

Our goal was indicated as **4A (Anyway, Anywhere, Anytime, Anyone)** learning environment.

The significance of our model is we only use “our new lecture table and internet resources” to meet all of the suggested needs. This means it did not cost much.
In Blended learning

- Interactive exchange of idea and information
  - Instructor ↔ Students
  - Assistant ↔ Students
  - Students ↔ Students

- To exchange the information, we need internet infrastructures
  - Multimedia Contents
  - on and offline Campus

Proper use of all possible resources in our learning environment.

Knowles (1975)
Brookfield (1986)
MATHRIX

for Windows

Built by the Delphi which is a programming language based on PASCAL.

Developed in 2000 for the windows 3.1 and 95.

http://matrix.skku.ac.kr/sglee/krf-1/linearalgebra/multi/mathrix/mathrix.htm
Using by graphic user interface, we can implement the visualization in our classes.

Applied to the development project approved by the Korea Research Foundation (KRF).
(Combined with the multimedia contents)

http://matrix.skku.ac.kr/sglee/krf-1/
Various Tools
Java Tools

JavaScript

Developed by Prof. M. Kazmierczak
(3x3 cases only)
Enhanced to the 4x4 matrix calculator
(1998-1999)

http://matrix.skku.ac.kr/sglee/4calculator.html
Various Tools
Java Tools

Java Applet Tools (2000~2001)

1) Linear system of equations (5 variables)
2) Determinant of the matrix (2x2-5x5)
3) Find the REF of the matrix (2x2-5x5, only square cases)
4) Find the inverse matrix (2x2-5x5)
5) Find the rank of the matrix (2x2-5x5)
6) Find the eigenvalues and eigenvectors (2x2-5x5)
7) Matrix Calculator (Gathering all functions)

Various Tools
Java Tools

JavaApplet

Matrix Calculator (2001)

Using the decomposition theories (LU, QR, SVD) on the matrix.

http://matrix.skku.ac.kr/sglee/krf-1/linearalgebra/multi/mc.html
http://matrix.skku.ac.kr/newMatrixCal/Test.html
Various Tools
Java tools

CurveFitting Applet
http://matrix.skku.ac.kr/sqlee/ejd/CurveFitting/CurveFittingApplet.html

Java Applet of the Gershgorin Circle Theory
Various Tools
Multimedia Contents with Java tools

Combined with the cartoons.
http://matrix.skku.ac.kr/ilas/er/module2/
Published on the ILAS (International Linear Algebra Society) Educational portal site.

Combination and permutation applet
Magic Square generator Applet
http://matrix.skku.ac.kr/sglee/skku-cal/Calculator.html
http://matrix.skku.ac.kr/nla/main/magicsquare.html
Various Tools
Multimedia Contents with Java tools

Developed in 2004, 2007
For the gifted students education, we make a simulation tools for the Blackout(Lights Out) game

http://matrix.skku.ac.kr/newJAVA/BlackOut/Test.html
Various Tools
Multimedia Contents with Java tools

Developed in 2006

Based on the Flash animation, we developed a new linear algebra multimedia contents.

To adapt new multimedia content, we developed more strong Java tools

1) Eigenvalues and Eigenvector (expand to 15x15)
2) Gauss Elimination (expand to 15x15)
3) Gram-Schmidt orthogonal process
4) Distance calculator between a line with a point
5) Finding Adjoint matrix
6) Encryption and Decryption Sampler
7) Determinant (expand to 15x15)
8) Inverse matrix (expand to 15x15)
9) Linear system of equations (expand to 15x15)
10) Power computation
11) Find the rank of a matrix (expand to 15x15)
12) Find the RREF of a matrix (expand to 15x15)
13) Find the area of triangle
14) Matrix Calculator (expand to 15x15)

http://matrix.sku.ac.kr/CLAMC/javatools/index.html
Part of other tools developed by us

**JAVA Matrix Computation Tool**, Java tools

<table>
<thead>
<tr>
<th>Linear Transformations (Visualization)</th>
<th>Visualizaion of Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complex Matrix Calculator(Int. Version)</td>
<td>Complex Matrix Calculator(K version)</td>
</tr>
<tr>
<td>Linear Algebra with JAVA tools 4x4,</td>
<td></td>
</tr>
<tr>
<td>JAVA Matrix tool v.1, JAVA RREF2, JAVA G-S. o.n. Prpcess</td>
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<tr>
<td>2004 MatrixCalculator, JAVA Matrix Eigenvale(Eigenvector),</td>
<td></td>
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<tr>
<td>Java Matrix Rank, Java Matrix Power, MatrixAdjoint, Det, LSE, TriArea</td>
<td></td>
</tr>
<tr>
<td>Gaussian Elim., Crypto, Inverse matrix, Java Crypto tools,</td>
<td></td>
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</tbody>
</table>

**JAVA Lightout Game 1**, m x n Blackout Game, **JAVA Math Collection**, Math Symbol writer 1 & 2, Grapher

Matrix Theory Web Contents (1st KMS Homepage Festival Silver Medal) Korea Research Foundation "LA Multimedia Contents Project";

K-10 MATH Project,

JAVA Calculator, **Java Grapher**, Curvefitting JAVA, Scientific Calculator, Factorial tool, Combination tool

http://galois09.skku.ac.kr/rpqgs/tpf/ (Random problem generators)
http://sagemath.ze.to/ http://math1.skku.ac.kr (LA with Sage) (test, test95)
Various Tools
Multimedia Contents with Flash Tools

Flash Animations

The flash has strong animation features, so it can be used to understand the difficult concepts in the mathematics classes.

We developed some flash tools to use in our classes.

http://matrix.skku.ac.kr/sglee/LT/index.htm
New Tools with Flash


New Tools for Self-Directed Learning –
Random Problem Generator

Self-Training Tools
http://matrix.skku.ac.kr/rpgs
http://matrix.skku.ac.kr/rpgs2/
http://galois09.skku.ac.kr/rpgs1.5/
Random Problem Generator 1.5 (with D.-S. Kim)

http://galois09.skku.ac.kr/rpgs1.5/

**Purpose:**
Support a stable service in RPG system.
Rearrange the many enhanced functions in RPG 2.0.
Intensify the automatic process in this system.
Simplify the HTML codes to use outside Korea.

Now this system is available on the ILAS Educational Portal Site.

http://matrix.skku.ac.kr/илас/er
Blended learning – Our Case!
New idea for the effective teaching with new our environment

Self-Directed Learning:
1) Recorded lectures
2) Multimedia contents
3) Self-training tools: Random Problem Generator, Sage-Math

1-week step for students in SKKU at Blended learning class
New learning environment
SKKU

http://vod.skku.ac.kr/studio/z_etc/e_lectureroom/index.html
### Contents and Movie for students

<table>
<thead>
<tr>
<th>Year</th>
<th>Subject</th>
<th>Links</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Solutions)</td>
<td>MT–Chapter 9 Solutions, Chapter 8, Chapter 7, Chapter 6, Chapter 5, Chapter 4, Chapter 3, Chapter 2, Chapter 1 All Solutions</td>
</tr>
</tbody>
</table>
Blended learning (Offline, Online) with Possible resources: Java, Flash, RPG, Sage etc

Sage in Korean, Mobile Sage Mobile and Ubiquitous
We found that if we want to have interactions with his students, now there are many ways.

Example: Over 5400 comments in QnA in my 2008 Fall linear algebra class with 90 students.

In order to make a mathematical discussion possible in LMS, Blog, BBS, we developed a typing system of mathematical symbols using the MimeTeX renderer in 2008.

http://mathsymbol.ze.to


(Solutions) MT–Chapter 9 Solutions, Chapter 8, Chapter 7, Chapter 6, Chapter 5, Chapter 4, Chapter 3, Chapter 2, Chapter 1 All Solutions
New Tool: Sage-Math : Online Open Source Tool

Sage-Math in Korea

http://math1.skku.ac.kr (Secured)
http://math2.skku.ac.kr (Free for anyone)

Purpose : Online Computation Tools

1. Localization: Complete!
2. Educational Implementation: in Process! (Covered all chapters of LA)
3. Goal: Ubiquitous Math!

Researches are on going.
New Tool: Sage-Math : Online Open Source Tool

Sage-Math in Korea

http://math1.skku.ac.kr
ID: test  PW: test95

Educational Implementations
- Visualization of Approximation (left)
- Visualization of Linear Transformation (below)

http://math1.skku.ac.kr/pub/
Various Tools
Sage-Math: Online Computation Tools

Sage-Math in Korea
With works in http://math1.skku.ac.kr

A text book "LA with Sage" is in process.
Linear Algebra with Technology

Flash Examples on CP

행렬식

\[ A = \begin{pmatrix}
  a_{11} & a_{12} & a_{13} \\
  a_{21} & a_{22} & a_{23} \\
  a_{31} & a_{32} & a_{33}
\end{pmatrix} \]

\[ \text{det}(A) = a_{11}a_{22}a_{33} + a_{12}a_{23}a_{31} + a_{13}a_{21}a_{32} - a_{11}a_{23}a_{32} - a_{12}a_{21}a_{33} - a_{13}a_{22}a_{31} \]
Ubiquitous Environments
Mobile Sage-Math and Mobile Flash Tools

Linear Algebra with Technology

Flash Grapher in Cell Phone
Ubiquitous Environments
Mobile Sage-Math and Mobile Flash Tools

Mobile Sage-Math Implementation

Mobile Sage-Math (with J.-Y. Park)

http://math1.skku.ac.kr/wap_html

This system provides the ubiquitous environments
(Most of cellular phones are available in Korea)
Some examples:

1) Find the determinant of a matrix
2) Find solutions of the given second order polynomial and its factorization.
3) Graph of the given function.
4) Limitation of the given formula and show the derivatives and integrations.

(We are working on this now!)

All of works for LA & students was enjoyable and rewarded.

Reason: Students appreciate it!
New learning environment
Sungkyunkwan University

2007–2008–2009 No. 1 Univ in NCSI

Sample LA lecture (Recorded)
The use of ICT (information and communication technologies) in education is becoming a major consideration of countries focusing on improving the quality of education. For those who like to learn mathematics these days, instruction excluded ICT implementations are not appreciated already because they know they need to use them at work.

We tried to share what we have experienced for teaching of Linear Algebra in our learning environment. It included Java, Flash, random problem generators and Mobile Sage.

Key words: learning environment, e-Campus Vision, blended learning, Mobile Sage
References


Thank you!

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Slide will be available on my website within a few days

http://matrix.skku.ac.kr/sglee/
and/or  http://matrix.skku.ac.kr/ilas/