Statement of Teaching Philosophy

Alexander Stoimenov

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1 Teaching experience

With a teaching load of (in average) 3-4 courses per semester over the past 9 years, I have now accumulated some teaching experience. In total I have taught over 40 regular university undergraduate courses, incl. two courses as a part-time lecturer in ICU/KAIST. These are fundamental courses like calculus and algebra (and a little bit of material included from other areas like some elementary number theory and topology). Before, I had given some more advanced short-term courses (of about 1/2 semester) on various topics, like specialized seminars on research (of others) in my field and writing papers in English. I have also, at numerous occasions, given personal advice to students regarding their research.

The following contains some words about my ideas concerning teaching, evaluation, and relations to students.

2 Teaching style

I try in my teaching style to mostly follow classical methods. In particular, I certainly use a blackboard extensively. Sometimes I have pre-prepared material, which I hand out and display when it is essential to emphasize and explain only certain parts of the text. For me it is important students to follow the lecture and it to be adequately organized, so that they can take notes and these notes to be of much use to them later. From my own experience as audience I was often overwhelmed with the speed in which slides have been exchanged, and so much of the essence of the presentation goes amiss. While for research talks this may be tolerable, I hardly imagine it appropriate for university courses. It does not mean that rigorous proofs must be provided anywhere. Sometimes the use and easiness to understand a statement stand in no comparison to the effort of its proof. But I prefer students to develop a good understanding of less material rather than a vague understanding or more. Examples are often far more useful than detailed arguments. In any case, for me the most important thing about teaching is that the students understand the lecture; without this teaching loses its meaning.

In pure mathematics courses, which I have taught, many topics can be covered (or better, one should strive to cover them) without calculators. Numerical bulk is seldom essential in conveying concepts or explaining solving methods, and beyond this calculators have tended rather to cripple than to spur a student's working skills. Certain subjects do require beyond-paper-and- pencil calculations. In such case I have presented the outcome in examples in class,

and left similar exercises to homework (where electronic access is no problem). At least for the time being it was possible to get along in exams without these devices.

I try to keep an informal atmosphere in the belief that this stimulates students to learn. Thus I try to have the class entertaining, but it should not be misconceived as entertainment - the students must keep the purpose of the whole process in mind.

3 Course organization

Much of the course is organized with particular orientation toward the exams. For some time, I have adopted to carrying out midterm and final exams in two separate parts: solution part and multiple choice part. Apart from this, there are quizzes and homework (usually 1 per week).

Quizzes and assignments are returned corrected in about 1 week. Students should not be bluntly penalized for doing something wrong, but rather explained what they did wrong and why, and how to make it better the next time. They should also have the right to inquire (and object) to grading. After quizzes and midterm (but, of course, not final) exam, I usually invest some time to discuss solutions (at least of problems which have generally created more difficulties). However, more recently I do resort to the math clinic TA hour. This is also the purpose of the solution sheets I prepare, on the basis of which students can discuss solutions with TAs.

A general mathematics course aims at developing a student's skill to deal with a certain type of calculation problems, and thus it is not realistic to evaluate performance without solution exercises. Grading of solution exercises is done mainly with respect to solving skill rather than final result. A proof or solution is deemed complete (only) if it includes enough detail so that I or a fellow-student can understand it without solving the problem (or doing any steps in its solution) by him/herself. That is, I can (and will) only evaluate what is on the exam sheet, and not what is in a student's head. A correct answer with no solution often brings few points. A(n otherwise correct) solution with one calculational mistake and incorrect answer can bring maximal points minus one. In general I allow in solution exam the use of student's own notes.

Multiple choice problems should refer to some theoretical knowledge and/or the capability (based on such knowledge) to observe certain facts without much calculation. There are multiple choice problems where one can see the correct answer directly, and such where one arrives at it restrictively (by seeing that the other 3 answers are wrong). At least a part of the problems should be designed so that there are alternative ways to arrive at (or at least get closer to) the solution. In a multiple choice exam, a student uses only a pencil and eraser.

4 Student supervision

Having been bound by contract to undergraduate teaching, I in particular actively seek opportunity to student supervision including Honors and Masters and vacation scholar projects, and ultimately PhD students.

The recordings of my talks at end of 2020 (as given in my CV) contain outline of some working projects with students, which I set out with the goal to both motivate students to work themselves into this particular topic, but also to be directly useful for my research work. (These recordings also provide some idea about my lecturing style, how I respond to students' questions, etc.) While I am open to students' problems at any time, I also advise students in such a way as to grow into independent researchers.

As far as teaching duties are concerned, my experience is that I can maintain a good relationship with students by being uncomplicated. It is clear that students often have other things on their minds, and it is important to be able to connect to them well. In most cases, students request meetings to have teaching material explained. My impression is that, whenever they

request such meetings, I can make them benefit from them. (But, again, often they meet the TA, who is better at Korean.)

I sometimes participated in class-unrelated activities. I also support students a few times with letters of reference if they request. I would always be ready to provide career guidance. While I have an own area of activity (and, for example, international connections), I find it important that students find out for themselves what they want to do, and I think that guidance has this ascpect of helping them in that realm as well.

5 Course topics

Classes with teaching experience: Ordinary Differential Equations, Mathematical English, Linear Algebra, Discrete Mathematics, Calculus and Applications, Vector Analysis, Introduction to Topology, Introduction to Algorithms
Classes wishing to develop: Measure Theory, Functional Analysis, Knot Theory, Digital Mathematical Writing

6 Online lecture

There are links to online recordings of a part of the algorithm class I managed (for computer science undergrads, with materials pre-prepared not by myself):
`https://www.youtube.com/playlist?list=PLvcvykdwsGNF9nmJpwXJklSCzstnFlNik`
(For this see also the “Teaching” section of my CV.)

7 Future Plans

7.1 Syllabus of lecture "Introduction to Computational Knot Theory"

The following is a rough content of a planned special lecture "Introduction to Computational knot theory" that I would be interested in developing, likely on a post-undergraduate level, to whet students’ interest in the topic and to potentially recruit students for joint research work.

1. Introduction to Knots and Braids
2. Diagrams, Reidemeister moves, DT code, Knot Tables
3. Flypes, Alternating diagrams, other moves
4. Colorings
5. Kauffman bracket and Jones polynomial computation
6. other link polynomials, braids
7. Skein tree algorithm, braid computations, braid index
8. Matrix algorithms (Smith normal form),
9. Goeritz matrix, Seifert matrix, signature computations
10. (knot group representations...)

7.2 Student projects

Below are few potential topics for student projects, with some emphasis on computational aspects. These projects can be on various levels: from 1-semester internship to PhD. Many of the topics could and should be developed further, depending on how collaboration with students progresses. Beyond this, I would especially encourage PhD students to work themselves into topics I am not very familiar with.

This is a link to a lab-internal recording (not very good quality) of a short talk with proposal for year/masters projects on computations related to knot theory (which elaborates on many of the below points): `https://youtu.be/SRAHAcyMafM`

7.2.1 Hybrid braid-skein computation of link polynomials

This can be a PhD project involving the integration of the advantages of braid- and skein-related recursive computation of link polynomials. Would require very detailed technical knowledge.

7.2.2 Computation of truncated link polynomials and braid index

One of the difficulties in computing the braid index is the need to compute polynomials of cable links. This computation can be reduced by computing only individual terms of the polynomials, which allows certain parts of the skein tree to be discarded. A detailed implementation of this would be at least a MSc, possibly also a PhD project.

7.2.3 Diagram moves and KnotScape's table location tool

KnotScape (`http://www.math.utk.edu/~morwen`) is one of the major computational software tools in knot theory, having the unique advantage to offer direct access to knot tables.

There is a long-standing problem of fixing the errors in the diagram move tool of KnotScape. This would require good knowledge of diagrammatic moves and notations. Likely on M.Sc. level.

7.2.4 Combinatorial computation of matrix- related knot invariants

A series of topics (semester project, extendable to MSc) of reliably implementing various operations (signature, Smith normal form) on matrices, with the goal of applying them to knot-diagram related matrices for computing knot invariants.

I successfully initiated the project with a masters student at KAIST, who implemented a fast and overflow-safe version of the determinant, signature, and torsion number calculation using the Goeritz matrix, as well as a(n integer) polynomial factorizer.

7.2.5 The KnotScape interface

This can be a semester-internship level project to learn how KnotScape's TCL shell invokes various components, and how to modify menus, functionality, etc.

8 Teaching evaluations and materials

The next page shows my teaching evaluations (in Korean) at GIST from the Spring and Fall semester 2019.

Courses are divided into GS (general studies) and MM (mathematics minor), and they are conducted simultaneously (though evaluated separately). The first four numerical columns indicate the number of students, the number of students entitled to submit an evaluation, the number of students who submitted an evaluation, and the evaluation participation rate. The

last 3 columns indicate the evaluation, the percentage (1=0%, 5=100%), and the ranking among all classes taught at the department. In 2019/1 I taught 2 sections of Differential Equations (2002) and 1 section of Calculus (1001). In 2019/2 I taught 2 sections Linear Algebra (2004) and 1 section of Topology (4016).

Then I append a small extract from teaching materials. Further information can be found on my (now old) teaching page `https://stoimenov.net/stoimeno/homepage/teach/teach.html`.

NO	개설학과전공	교과평가유형	교과목-분반	교과목명	담당교수	수강인원	평가인원	참여인원	참여율	강좌총점	강좌평균	평균평점	백분율	순위
1	기초교육학부	강의과목	GS2002-02	미분방정식과 응용	스토이메노프	14	14	11	78.57	549	49.91	4.54	90.75	43/99
2	기초교육학부	강의과목	GS1001-01	미적분학과 응용	스토이메노프	24	24	19	79.17	941	49.53	4.5	90.05	47/99
3	기초교육학부	강의과목	GS2002-01	미분방정식과 응용	스토이메노프	12	12	8	66.67	382	47.75	4.34	86.82	64/99
4	수학부전공	강의과목	MM2002-01	미분방정식과 응용	스토이메노프	2	2	2	100	101	50.5	4.59	91.82	5/12

NO	개설학과전공	교과평가유형	교과목-분반	교과목명	담당교수	수강인원	평가인원	참여인원	참여율	강좌총점	강좌평균	평균평점	백분율	순위
1	기초교육학부	강의과목	GS2004-01	선형대수학과 응용	스토이메노프	5	5	5	100	266	53.2	4.84	96.73	13/106
2	기초교육학부	강의과목	GS4016-01	위상수학 개론	스토이메노프	2	2	1	50	49	49	4.45	89.09	71/106
3	기초교육학부	강의과목	GS2004-02	선형대수학과 응용	스토이메노프	14	14	10	71.43	474	47.4	4.31	86.18	83/106
4	수학부전공	강의과목	MM2004-01	선형대수학과 응용	스토이메노프	1	1	1	100	55	55	5	100	1/10
5	수학부전공	강의과목	MM2004-02	선형대수학과 응용	스토이메노프	1	1	1	100	54	54	4.91	98.18	3/10
6	수학부전공	강의과목	MM4016-01	위상수학 개론	스토이메노프	3	3	2	66.67	107	53.5	4.86	97.27	4/10

GS1001 Calculus and Applications Spring 2019

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Office: GIST College A 212
Office hour: per appointment (see 'Organisatory')

Warning: DO NOT seek my email under "알렉산더"; you get the address of Prof Alexander Azhbanov (azhbanov@gist...). He turned into an unpaid secretary of mine forwarding me diverse messages of yours. Maybe I can be found under "스토이메노프"? Read about this class rules below.

Class room and hour

Mon/Wed 9:00-10:15 (Sect. 1);

GIST College A 223

Recitation (*I supervise recitation myself!*)

Wed 17:30-18:20 (Sect. 1);

GIST College A 225

Course description

This course deals with basic material on analysis of one-variable functions, and related topics of point-set topology. The purpose is also to prepare a student to apply differentiation and integration methods to determine area, length, volume, evaluate Taylor series, solve simple differential equations, etc. Prerequisites are high-school level Calculus and some Linear Algebra.

Textbook

1. *Calculus*, by James Stewart (7 edition), Brooks Cole, English version
2. *Calculus I,II*, by Tom A. Apostol

Grades (tentative)

Class attendance	5 %	Final exam	50 %
Midterm exam	25 %	Recitation	10 % (5% att.+5% sheet score)
Homework	5 %	Quiz	5 %

Class week (days)		Topics
1		—— Recess ——
2	(3/4, 3/6)	Organisatory, Basics of sets, numbers, infimum and supremum
3	(3/11, 3/13)	functions, domain, target, basic properties and basic examples
4	(3/18, 3/20)	sequences, limits, open and closed, compact sets
5	(3/25, 3/27)	limits of a function, continuous function, derivatives,
6	(4/1, 4/3)	Integrals and FTC, improper integrals,
7	(4/8, 4/10)	Logarithm, exponential, and inverse trigonometric functions,
8	(4/15)	——Midterm Exam——
9	(4/22, 4/24)	hyperbolic functions, integration theory
10	(4/29, 5/1)	polar integration, applications of integration,
11	(5/8)	separable ODE, first order linear ODE, second order linear ODE, (5/6 —— Recess ——)
12	(5/13, 5/15)	Complex numbers, infinite series, telescoping, geometric series,
13	(5/20, 5/22)	Sequences and series of functions, pointwise and uniform convergence,
14	(5/27, 5/29)	Power series, circle of convergence, Taylor formula,
15	(6/3, 6/5)	analytic functions, defferentiation and integration of power series
16	(6/10)	——Final Exam——

Organisatory

First, let me say why this section is long and why I nevertheless like you to read and understand it.

On the one hand, the ***language problem*** always complicates communication. It is that much more important to clarify certain matters in advance for everyone to know, so that confusion is minimized. On the other hand, when only a few students are left behaving badly, this deteriorates the atmosphere in the entire class. Students also often seek to convenience themselves with little concern for the rest of the class. Therefore, it is critical to maintain ***discipline***. Over the time I have experienced loose manners surfacing in a number of ways. The below instructions are meant to prevent or handle these occurrences – and not scare you and to justify that I am particularly tough or unpleasant. *If you join the class, I'll assume that you have read and agree on these rules.* In many cases I receive requests about something directly explained in these rules, so do not wonder that I just reply by referring to them.

1. This syllabus is still subject to minor updates/corrections until the semester starts, but by any means should override the outdated official course syllabus you'll find in

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Organisatory

The rules written below for TAs apply almost identically to Working scholarship students (WSS), except where I note this explicitly.

Working period

1. Regardless of your official contracting period, I expect TAs to work 4 full months, i.e., until the end of June/December. (While there is comparatively little work the first weeks, expect a lot of work from exam week on!)

GEL

2. **GEL** and my own teaching page, http://stoimenov.net/stoimeno/homepage/teach/teach.html, have almost all class-related information, and it is important that the TA follows announceents on them. I will try to get TA access to the GEL page of the course, but if this fails, the TA should ask the administrator.

Grading rules

3. TA's main job is **grading**. Each class usually has homework, recitation, and quiz most of the lecture weeks, as well as a two-part (solution and multiple choice) exam in midterm and final. A TA should expect to grade all of this, although the work is divided among multiple TAs and sometimes I take over a small part.

4. Evaluation and score penalty rules are designated in the syllabus (uploaded on GEL/teaching page) and the TA should get him/herself familiar with them (in addition to the rules on this sheet).

5. The TA should write on each graded sheet the total score of the form 'number of points/full points' as well as his/her name on the top of the first page of the sheet. He/she should write the score of each solution exercise in the same form 'number of points/full points', at the place where that exercise appears in the sheet. For a multiple choice problem, only the number of points (always -1, 0 or 5) should be written (at the place of the problem).

GS2002 ODE Spring 2019

YOU WRITE SOLUTIONS ON SEPARATE SHEETS; IF YOU WRITE ANSWERS OR SOLUTION ON THIS SHEET, THEY WILL NOT BE EVALUATED. WRITE NAME (HANGUL), DEPT./YEAR, STUDENT #, SECTION # ON EACH SHEET YOU SUBMIT!

Homework-03 (6 problems, 110 points, 100%=40 points) due Mar 27

Problem 1. *(10 points)* Test for exactness. If exact, solve. If not, use an integrating factor as given or find it by inspection or from the theorems in the text. Also, if an initial condition is given, determine the corresponding particular solution.

$$(e^y - ye^x)dx + (xe^y - e^x)dy = 0$$

Problem 2. *(5 points)* Are the following functions (for $a \neq 0$) linearly independent on the given interval?

$$e^{ax},\ e^{-ax} \text{ (any interval)}$$

Problem 3. *(5 points)* Find an ODE

$$y'' + ay' + by = 0 \qquad (*)$$

for the given basis $\{1,\ e^{-3x}\}$.

Problem 4. *(15 points)* Consider the functions (with $\omega \neq 0$)

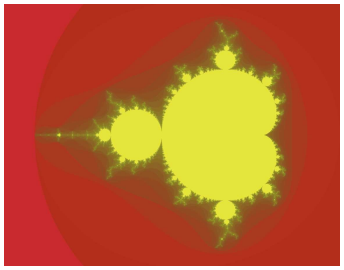
$$e^{-2x}\cos\omega x,\ e^{-2x}\sin\omega x\,. \qquad (\dagger)$$

(1) *(7 points)* Find an ODE $(*)$ for which the functions $(\dagger)$ are solutions.

(2) *(8 points)* Show linear independence of the functions $(\dagger)$ (a) by considering quotients, (b) by Wronskian.

Problem 5. *(50 points)* The *Mandelbrot set* $\mathcal{M} \subset \mathbb{C}$ is defined as

$$\mathcal{M} := \left\{ c \in \mathbb{C} : \begin{array}{l} \text{the sequence } (a_n) \text{ with } a_0 = c \\ \text{and } a_{n+1} = a_n^2 + c \text{ is bounded} \end{array} \right\}$$



(1) *(10 points)* Prove that $|c| \leq 2$ for all $c \in \mathcal{M}$.
Hint: prove by induction $|a_{n+1}| \geq |a_n|(|c| - 1)$ when $|c| > 2$.

(2) *(10 points)* Prove that $c \in \mathcal{M}$ if and only if for all n, we have $|a_n| \leq 2$.

(3) *(30 points)* Identify $\mathcal{M} \cap \mathbb{R}$ (1 point) and give an argument (29 points).

Problem 6. *(25 points)* Consider the iteration $a_{n+1} = a_n^2 + c$, with $a_n, c \in \mathbb{R}$.

(1) *(5 points)* What are the fixpoints of this iteration?

(2) *(20 points)* Determine the stability of each fixpoint when
(a) $c = \dfrac{1}{4}$ (5 points), and (b)* $c = -2$ (15 points).