TEACHING STATEMENT

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1 TEACHING PHILOSOPHY

Two of the most common positive attributes that shows up in my teaching feedback are "inspiring" and "independent thinking". I believe that *a great teacher should inspire* and to achieve this, teaching can not be merely a one-way dialogue. It should lead to invigorating discussions, allow students and teachers to share their passion and enthusiasm for a topic, and let students be inspired to realize their true potential. I rely on the *culture of care* to nurture an atmosphere of trust between the instructor and the students. In particular, I follow the Socratic style of teaching, and I employ problem-solving as a principal scaffolding technique. *Pre-lecture*, I perform extensive background research to provide a holistic view of the content, including historical and social contexts, behind the origin of concepts. Having an overarching view of the development of ideas allows students to view the material through the lens of the concepts' creators, and thereby understand the process of creation of concepts. *During the lecture*, I employ gamification-based methodology wherein I often try to convince students of a wrong proof/algorithm. Once students discover the bugs in the wrong proof, we work towards designing the correct proof/algorithm, which involves stimulating in-class discussions allowing students to absorb the need for rigor in logical arguments.

Assessment Design A significant challenge in teaching to large cohorts is addressing the large spread in the technical strengths of students to ensure that every student can rise to their true potential. To this end, I offer students choices among projects with different difficulty levels, thereby providing an avenue for stronger students to choose more ambitious projects while ensuring that weaker students still achieve primary learning outcomes. Furthermore, while I publish concrete requirements for project deliverables for the students to achieve A grade, the requirements for A+ are left open-ended. I firmly believe that when students are challenged constructively, they will often exceed the expectations. In particular, two of the class projects in my course in Fall 2019 targeted to the Ph.D. students led to two publications at top-tier conferences (NeurIPS-19 and LPAR-20).

Content Structuring For lower-level undergraduate courses, I focus on highlighting the underlying generality of the concepts and their practical applications. Over the past four years, I have continually developed an unconventional but effective design methodology of tutorial assignments for upper level undergraduate courses. The methodology focuses on using tutorial assignments as anchors for concepts to be introduced. To this end, a significant fraction of questions in tutorial assignments are designed in a way that they could be solved sub-optimally by concepts covered until the tutorial but their optimal solution would require knowledge of concepts yet to be introduced. Successful execution of the strategy required organization of the entire course content into three blocks such that for each of the blocks, the lectures build on each other. I also ensure that the tutorial for week X is scheduled before the lecture for week X; therefore, the students are not exposed to the content of the week X lecture at the time of week X tutorial. Therefore, the students would be able to apply the already learned concepts but would realize the weakness of the concepts taught so far as those concepts provide unsatisfactory answers. Furthermore, the questions are designed in a way that the student should be able to work out simple cases by hand and notice the patterns that lead to new techniques to be introduced in the upcoming lecture.

Impact Evidence My teaching experiences have taught me that teaching is an art honed by experience, external feedback, and personal reflection. Overall, I received the **Faculty Teaching Excellence Award** for the academic years 2019/20 and 2020/21. The peer review has highlighted the effectiveness of my teaching style. Quoting peer-review: "Kuldeep's constant encouragement of students to think and to question assumptions and flaws in proofs, are testament to his ability to engage the students. ...this style of teaching encourages the students to think for themselves and be independent learners, taking charge of their own learning. "

The (anonymous) student feedback further highlighted the impact of teaching style: (1) "...He is able to cultivate deep interest in students. I find myself looking forward to his 3 hour lessons almost every week, and every single time I leave the seminar room feeling inspired, challenged and curious. It is a shame that this is the last

module I can ever take from him." (2) "He encourages his students to not merely remember the content, but to think carefully about the content and come up with the formulation/derivation themselves. This has helped me to understand not only what the concept is about, but also why was the concept derived the way it was." (3) ".....He pushes the students to think independently and encourages learning for the sake of learning. He seems to be able to infuse strong interest and desire to learn even in a module that some may consider very foreign and distant. To put it simply, his teaching style is rare but relentless and inspiring." (4) "The tutorials are very well designed, and each tutorial introduced a new concept that builds on top of the previous lessons. These are some of the few tutorials that students may look forward to, and consistently be very curious about the results." (5) "... While his modules are difficult, it is a joy to be in because you will always discover things that make you go wow."

2 TEACHING PORTFOLIO

My teaching experience spans undergraduate and graduate courses[1]:

- *Introduction to Artificial Intelligence* in Fall 2020 (210 students) and Fall 2021 (156 students)
- *Knowledge Representation and Reasoning* in Spring 2018 (28 students), Spring 2019 (26 students), Spring 2020 (34 students), Spring 2021 (37 students); a course targeted to final-year undergraduate students
- *Fundamentals of Logic in Computer Science* in Fall 2019 (14 students); a course primarily targeted to first-year graduate students.
- *Logic in AI* in Fall 2018 (18 students); a course primarily targeted to Ph.D. students.

I summarize the content of each of the above courses and the student feedback evaluation below. All the registered students are invited (and encouraged but not required) to fill the course evaluation at NUS. A student rates a teacher's overall effectiveness on a scale of 1 to 5 and may also nominate the instructor for a teaching award. The CS department's average teacher effectiveness score has ranged between 4.0 to 4.2 in the past four years.

2.1 CS4244: Knowledge Representation and Reasoning

This is a course targeted at final-year undergraduate students and is offered yearly. The desired learning outcomes of the course are three-fold:

- Understand the need for different representations such as propositional, quantifiers, defaults, and negation.
- Understand the complexity and algorithmic techniques behind reasoning techniques for propositional, first-order logic, defaults and negation.
- Appreciate the tension between expressibility and computational complexity.

In Spring 2018, I co-taught the course with Dr. Henry Chia. At that time, the course was titled *Knowledge-based Systems*, and its contents had not been revised for a long time. Based on the feedback from students and colleagues, I updated the course content and renamed the course to *Knowledge Representation and Reasoning*. Starting Spring 2019, I have been the sole instructor for the course. The revised course has been appreciated by students, as reflected in their student feedback evaluation quantitatively and qualitatively. A summary of the quantitative evaluation is presented in Table 1. **The offering in Spring 2021 received *the highest teaching effectiveness rating* among all the offerings of CS4244 in the past decade.** My teaching in CS4244 contributed to me receiving **Faculty Teaching Excellence Award** for the academic years 2019/20 and 2020/21.

Semester	# of students	# Respondents	Mean Effectiveness	Nominations
Spring 2018	28	14	3.9	3 ($\approx 21\%$)
Spring 2019	26	9	4.6	5 ($\approx 55\%$)
Spring 2020	34	22	4.2	11 ($\approx 50\%$)
Spring 2021	37	21	**4.7**	12 ($\approx 57\%$)

Table 1: Student feedback for CS4244: Knowledge Representation and Reasoning

[1] At NUS, a course is referred to as a *module*.

2.2 CS3243: Introduction to Artificial Intelligence

CS3243 is an introductory course in the area of artificial intelligence primarily targeted at second and third-year undergraduate students. The course content introduces several topics: uninformed search, informed search, local search, constraint satisfaction, stochastic environments, reinforcement learning, Bayesian networks, adversarial search, and knowledge representation.

Semester	# of students	# Respondents	Mean Effectiveness	Nominations
Fall 2020	204	133	3.2	15($\approx 11\%$)
Fall 2021	156	91	**4.5**	29 ($\approx 32\%$)

Table 2: Student feedback for CS4244: Knowledge Representation and Reasoning

I co-taught CS3243 with Dr. Daren Ler in Fall 2020 and served as the sole instructor in Fall 2021. As reflected in Table 2, the teaching ratings in Fall 2020 were below the department average. I worked with teaching mentors and peers to identify primary areas of improvement: the limitations of lifting whiteboard teaching to iPad and the need to revamp tutorial assignments. I augmented virtual whiteboard teaching with slides in the subsequent iteration and revamped all the tutorial assignments. **The subsequent offering in Fall 2021 received *the highest teaching effectiveness rating* among all the offering of CS3243 in the past decade.**

2.3 CS6283: Logic in AI

The course CS6283 is an advanced course targeted to Ph.D. students, and the particular topic is chosen by the faculty member offering the course. I focused on logical methods in artificial intelligence, in particular symbolic reasoning. In the first half of the semester, I covered the fundamentals of symbolic reasoning, while the second half of the semester focused on the student projects. Two of the projects were subsequently published as research papers at **NeurIPS 2019** and **LPAR 2020**.

Semester	# of students	# Respondents	Mean Effectiveness	Nominations
Fall 2018	18	13	4.1	9 ($\approx 70\%$)

Table 3: Student feedback for CS6283: Logic in AI

2.4 CS4269/5469: Fundamentals of Logic in Computer Science

While teaching CS6283, I observed the lack of a graduate-level course focused on the foundations of logic. I created a new course on *Fundamentals of Logic in Computer Science* in Fall 2019 with three-fold learning objectives:

- Develop a rigorous understanding of syntax and semantics of propositional and first-order logic.
- Understand soundness and completeness of different proof techniques
- Understand decision procedures for satisfiability of propositional and first-order logic.

The course is targeted at final-year undergraduate and first-year graduate students, and the first iteration received an encouraging response.

Semester	# of students	# Respondents	Mean Effectiveness	Nominations
Fall 2019	14	6	4.5	–

Table 4: Student feedback for CS4269/5469: Fundamentals of Logic in Computer Science

3 ADVISING

Experience I have advised five post-docs so far: G. Kumar (co-advised with D. Chakraborty), L. Kanesh (co-advised with D. Chakraborty), V. Sivaraman, J. Bendik, Y. Lai(co-advised with R. Yap). Lai is currently an

associate professor at Jilin University while Sivaramn is an **assistant professor** at IIITH Hyderabad. Kanesh will be joining U. Warwick for another post-doc and Bendik is a post-doc at MPI-SWS.

I currently advise **eight Ph.D. students**: T. Baluta (co-advised with P. Saxena), B. Ghosh, P. Golia (co-advised with S. Roy), M. Kabir, Z. Pang, Y. Pote, Y. Suwei, and J. Yang. Baluta, Ghosh, Golia, and Pote are expected to graduate within next two years. I am most proud of the achievement of my students: Baluta and Yang were awarded Presidential Graduate Fellowship; Baluta also received **Google PhD Fellowship**. Suwei joined my group as an undergraduate, and subsequently joined the Ph.D. program in Aug 2019; he was awarded **Outstanding Undergraduate Research Award** (university level) for his undergraduate thesis work. I have advised five Masters students: S. Sharma(co-advised with S. Roy), R. Gupta(co-advised with S. Roy), A. de Colnet, D. R. Christian, and L. Ciampiconi (Politecnico di Milano).

Style I view my primary objective as an advisor is to enable my students and postdocs achieve their potential. Since every advisee is different, it is important to be flexible: therefore, for some advisees, my advising style is more hands-on while for some other students, I take a more hands-off approach.

I have observed that students are able to deal with uncertainties better if they have had a taste of *success* early on, as such success acts as a strong confidence booster. To this end, I play a very active role in designing the first project a student takes on after joining my research group. In particular, I *prefer* their first project to be on problems for which I am reasonably confident of a top-tier publication within 12-18 months. Upon completion of the first project, I encourage students to take more active role in selection and design of problem statements. It has become common for graduating PhD students to have significantly more publications than what used to be the norm a decade ago. The raised expectations may put too much pressure on the students, which may make them to look out for *low-hanging* fruits repeatedly and not experience the real joy of doing research in the first place. I consider my job as an advisor to shield them from such pressure early on in their PhD studies. To this end, our research group culture strongly encourages students in their second and third year of PhD studies to explore different topics and gain deeper technical insights. Finally, as students reach the final stages of their Ph.D., I work with them to focus their efforts so as to have a cohesive thesis.