An old discipline with a new twist: the course "Logic in Action"

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Abstract

What are the basic logical notions and skills that all beginning students should learn, and that might stay with them as a useful cultural travel kit for their lives, even when an overwhelming majority will not become professional logicians? "Logic in Action" http://www.logicinaction.org/ tries to convey the idea that logic is about reasoning but also much more: including information and action, both by individuals and in multi-agent settings, studied by semantic and syntactic tools, and still confirming to the standards of precision of an exact and mathematized discipline. Viewed in this way, modern logic sits at a crossroads of disciplines where new developments occur every day. I will explain the ideas behind the course, which combines predicate logic with various modal logics, its current manifestations and dialects in Amsterdam, Beijing and the Bay Area, and its future as an EdX pilot course.

1 History of the course

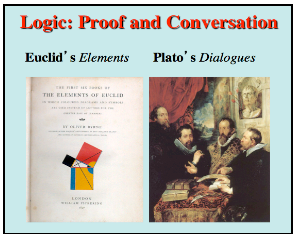
There is a thriving international market of new on-line logic courses today. Roughly speaking these endeavors fall into two kinds. Sometimes the new technology is used to create high-tech versions of largely standard fare in the traditional curriculum with, say, sophisticated graphics interfaces for classical natural deduction proof systems, like a Latin Mass with rock guitars. But sometimes also, there is ideological fervor: the course designers have a special research agenda, modifying or changing existing curricula, and want to export their revolution by by-passing the academic colleagues and instead of that, influencing the youth. The course *Logic in Action* falls in the second activist category, and we will put our cards on the table in a moment. The course arose in the education group of the Spinoza Award project "Logic in Action" (1997–2002; http://www.illc.uva.nl/lia/) of the Dutch Science Organization, and it received a crucial push by a grant from the Dutch Ministry of Economic Affairs in its program Creative Technologies meant to improve the national information infrastructure.

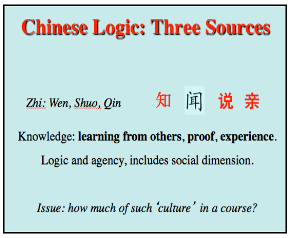
2 The main idea: a broader scope for logic

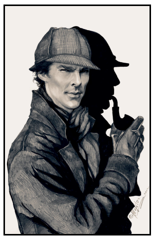
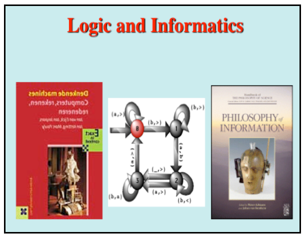
Traditional logic courses emphasize the study of correct inference patterns as the core business of logic, with propositional and predicate logic as paradigms of the methodology for doing so. Students are trained in basic skills such as translating natural language sentences into formulas, validity tests such as truth tables, and often also, calculi for formal deduction. In our view, this agenda instills a large number of attitudes, often as hidden presuppositions. Let us contradict a few such subliminal messages. First, inference is just one topic in logic, and just as important are definability and computation, a point made already in E.W. Beth in the 1960s when reflecting on the history of logic and its modern branches of proof theory, model theory and recursion theory. Next, there is little reflection on what intellectual assets are actually activated by training in formula translation or formal proof. It is unclear whether there is any transfer to broader skills, and it may be significant that research logicians themselves never seem to use them. Moreover, the emphasis on formal proof somehow suggests that mathematical activities are the highest point of logical intellectual skills, something which is as debatable as thinking that the best test of someone's moral fiber is her behavior in church. Finally, the emphasis on teaching complete logical systems as the locus of logic is a very peculiar methodology, different even from the problem solving skills taught in mathematics and sciences courses: one comes for a formula or two in the store, but one has to buy a huge supply and worry about its staying fresh for years and decades.

Raising such concerns does not mean that there is something wrong with the traditional curriculum in logic, only that the discipline has much wider scope than what it might suggest. The major aim of the course *Logic in Action* is conveying this broader picture from the start as being much more true to what logic is today and what its range is across the university and elsewhere. If we do not get this across at base level, students will either not see what logic is really good for, or, they will develop a narrow conception of the field which then keeps them locked afterwards into biased philosophical or mathematical conceptions.

One way of achieving this mind-opening is by shifting the emphasis from inference to a much broader range of *informational activities* as the subject of logic. Besides inference, such activities also include making observations and doing experiments, asking questions and processing answers, and engaging in communication generally. Therefore, the course treats two realms on a par, purely deductive inference, and intelligent conversation, as highlighted here in the following picture of Euclid's *Elements* versus Rubens' painting 'The Philosophers'.





Interestingly, these three sources are already present in ancient Chinese logic, witness a famous dictum in the Moist School (500–300 BC, around the time of Aristotle) that knowledge comes from three sources: hearing from others, demonstration, and experience. Of course, this quotation is chosen with a side purpose: make it clear to students that they are in a worldwide cultural stream, not just into ancestor worship of Greek Antiquity. The course has many more such side themes, all aiming at installing some more general erudition. But of course, we also emphasize that inference and observation are on a par in modern science, or in more playful mode, in the tales of that logical detective Sherlock Holmes whose success shows that, far from the usual view of logic as organized pedantry, logical skills are not just duties that we perform, but also talents that we appreciate and that even give us pleasure.

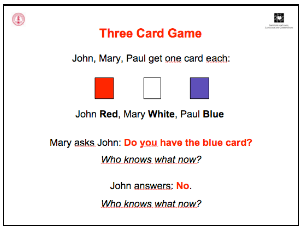
One general way of thinking about what is said here again goes back to a pervasive feature of logic throughout its history, and something that even surfaces in many hardcore textbooks. One can think of logic as describing the most general structure of the universe and its inventory of atomic, negative, or disjunctive facts, individual and general facts. In that metaphysical sense, logic would be there even if there were no human beings at all, as on the cold and lonely planets we see in astronomical documentaries. One can soften this a bit in terms of information available in the world (another view of logic that can be found in textbooks), but again this information would be there even if there were no human agents picking it up. But there is also another stream, right from the start of the discipline, of logic as manifesting itself in activities of conversation and dialogue, whether cooperative or competitive. On this agency view, logical laws are about moves and strategies toward winning in dialogue games, and the very logical constants now correspond with structured actions in argumentation or conversation. On this view, then, communication and strategic interaction are crucial to logic, and the patterns described by logical systems may just as well be forms of behavior as forms of language or of the world. *Logic in Action* emphasizes the second view as much as the first.

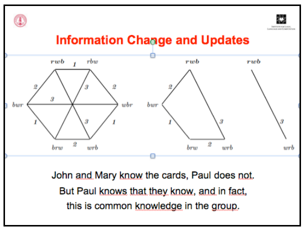
This broad view comes with a wide canvas of disciplines that modern logic interacts with. While students in many disciplinary courses taught today, be they mathematicians, philosophers, linguists, or whatever, may be told that logic is typically 'theirs' (with only rumors of occasional lapses into other fields), the reality of the discipline today is that it interacts with, feeds into, and is inspired by contacts with the age-old interfaces of philosophy, mathematics, but just as much with computer science, linguistics, and in recent years, to some extent also cognitive science. In particular, in the view of this course, *computation* in a broad sense is as much a core concern of logic as proof or definability, as is reflected in the fact that probably most logic research today takes place in computer science, including some of the most innovative frontiers. This is the intellectual environment that we want to convey in this course: logic is one's ticket to broadmindedness, not one particular disciplinary lifestyle.

3 A broader range of logical skills

In terms of paradigmatic examples of logical acts, then, a question is as basic as an inference. And likewise, a strategy is as important as a proof, say, as a way of guiding communication or argumentation. An appealing aspect of this multi-agent interactive view is that set pieces of logical reasoning become much more interesting and appealing than the usual syllogisms or Boolean inferences. Here is a typical challenge, somewhat of a classic by now. Much reasoning in daily life is not just about the facts, but also crucially involves what we know about others.

The Cards. Three cards 'red', 'white', 'blue' are given to three children: *1, 2, 3*, one each. Players see their own cards, not the others. The real distribution over *1, 2, 3* is *red, white, blue*. Now a conversation takes place: " *2* asks *1*: "Do you have the blue card?" And *1* answers truthfully: "No". Who knows what during this conversation? Assuming that the question is sincere, *2* indicates that she does not know the answer, and so she cannot have the blue card. This tells *1* at once what the deal was. But *3* did not learn, since he already knew that *2* does not have blue. When *1* says she does not have blue, this now tells *2* the deal. *3* still does not know the deal; but since he can perform the reasoning just given, he knows that the others know it.



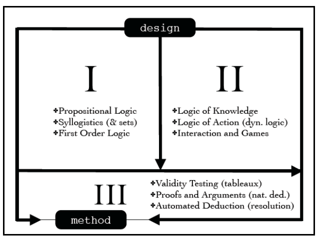
Humans often go through this sort of reasoning, with different knowledge for different agents acting as the driving force for communication. Moreover, puzzles like this pose challenges that people find interesting, witness the discussion of the solution of the Cheryl Birthday Puzzle https://en.wikipedia.org/wiki/Cheryl%27s_Birthday, a knowledge problem that went viral this spring after appearing on a talk-show in Singapore. This is logic in action at a challenging level. And it involves a skill not usually taught in introductions to logic, namely, the ability to *model a given scenario* in a concrete semantic manner. It is not hard to see that we can model the Cards as a set of six alternatives (the possible deals), related by easily drawable uncertainties for players. E.g., *2* cannot tell ***rwb*** and ***bwr*** apart if she finds herself in either of these deals, but *1* and *3* can. The information flow in the example can then be made very concrete in terms of update: *2*'s question removes ***rbw***, ***wbr***, reducing the range to four options, *1*'s answer removes ***bwr***, ***brw***, and we are left with {***rwb***, ***wrb***} in which *1* and *2* know the cards, *3* does not, though *3* does know that the others know, which is non-trivial information in itself.

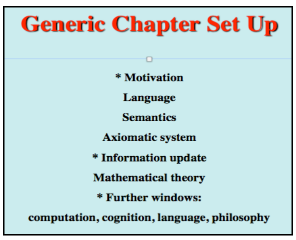
Aside. Incidentally, one of the things that makes teaching unusual material like this attractive is that students often come up with new angles immediately. Recently, a student observed that Child 2 does not even need to answer the question, but only has to say that he knows the cards, and Child 2 will know the cards as well. This then raised interesting general discussion about how epistemic information can replace factual information in communication.

So, what skills do we expect students to learn in the wider world of this logic course? Certainly, we do not want to give up on traditional logical virtues, such as precision, systematicity in logical systems, and a sense of the beauty of abstract mathematical formulations. Such things will also have to be, and can be, supplied for the further tasks mentioned here. But in addition, we want modeling skills that go beyond the usual core. For instance, we do not want routine translation of the text of the Cards scenario into formulas, but a sensible paraphrase into essential formulas, the way we also use mathematical equations to model physics problems. And more than that, we want a semantic model for the setting, and based on that, a semantic understanding of the relevant information flow, tied to real problems. And finally, we want the students to understand some basics of the computational structure and complexity of the informational processes that form the topic of logical study.

4 Contents and chapter structure

But now it is time to come down to earth from these grand ambitions. How can we teach the above set of themes and skills? Perhaps the most obvious approach is to merely extend the standard curriculum. In a way, the list of chapters to be given here has that feature. The course *Logic in Action* has two main parts, the first of which contains basics of *propositional logic*, the *syllogistic* as a first extension toward objects and predicates, and then *first-order logic*. These systems are presented as progressively richer ways of describing the world, be it either physical or conceptual space. After that, the second part of the course is devoted to the main ingredients of information-driven agency. A first chapter on *epistemic logic* focuses on semantic modeling of information, including knowledge that agents have about facts and about knowledge of other agents. Next to get at the dynamics of the actions involved in communication, and agency in general, a chapter on *dynamic logic* gives a standard base logic of structured computation. Finally, the two strands of information and action are brought together in a chapter on *logic and games*, as a grand finale to the course where preferences come into the picture, as well as the fundamental notions of strategy and equilibrium. There is also a third part in the course material, but we will get to its rationale below.

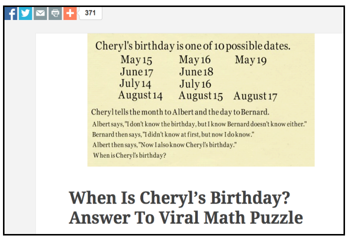


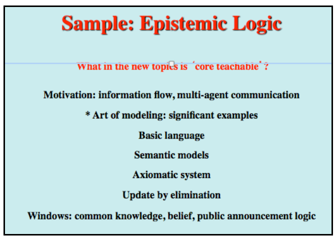


This article is not the place to give the precise details of these six chapters, for which we refer to the website http://www.logicinaction.org/ and the free textbook *Logic in Action* that can be downloaded here: http://www.logicinaction.org/docs/lia.pdf. For here, we mainly explain something about the general design of the core chapters. First of all, a major choice had to be made. If we keep the usual content of the first chapters the same, then a course like this will become very heavy, and also, we miss an opportunity to remove historical clutter from the old curriculum. But if we rethink things more radically, then hard and perhaps controversial choices will have to be made. Do we still teach translation from natural language to formulas with the usual drill? Do we teach formal deduction in great detail, despite legitimate concerns about its broader transfer value, or its adequacy as a model for what mathematical proof really is? If we stick to the standard size of a core course, then something has got to give.

In our core course, we have economized mainly on extensive translation drill, and on proof skills, though they are not gone completely. In particular, we have kept some axiomatic calculi to at least familiarize the students with the important intellectual idea of a symbolic un-interpreted systems view of deduction. We have also economized on the usual formal set-theoretic presentation of the model-theoretic semantics for first-order logic, which is often a stumbling block for students anyway making something that they already understand intuitively look weird and exotic. But the course does not become easier in this way, since the content presentation structure for these topics in Part I now carries over to the new topics of Part II. Moreover, for students or teachers who just cannot relinquish traditional skills, or who have time to spare, we have collected three major methodological tools in Part III, with chapters on *proof systems*, *computation and programming*, and *semantic tableaux*.

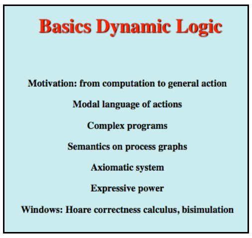
Our longer set of topics runs a risk of incoherence and incongruity since its scope is so wide. To increase a sense of uniformity for the student, all chapters, no matter how different their topics and logical systems, have been set up in a similar manner, with repeating sections called *Motivation*, *Language*, *Semantics*, *Axiomatic system*, *Update*, *Mathematical theory*, and *Further windows*, with illustrations oriented toward the intellectual environment of logic in computation, cognition, language, and philosophy. Let's describe the generic structure of two chapters to illustrate this. In the chapter on propositional logic, motivations are classifying of structure in the world as well as patterns in argumentation, language introduces the idea of abstract symbolic syntax as a major historical achievement, and models are of course the evergreen of truth tables. For an axiomatic system we teach some Hilbert-style formula manipulation, which also gets students used to idea that finding proofs is not trivial. A new feature is the idea of information update where new information decreases a current range of options, and we show how some puzzles can be solved either by deduction or by update to one single remaining option. This shows the semantics at work in a way that students find appealing, while the harmony of semantics and proof theory also features concretely. In a section on mathematical theory we introduce definability of connectives, and soundness and completeness. Finally, windows in this case are toward the usual puzzles, but mainly toward computation: networks for Boolean algebra, and complexity including the P=NP problem. After all, propositional logic is deeply connected with the emergence of computer science. Of course, these illustrations can, and will touch on other disciplines in other chapters.

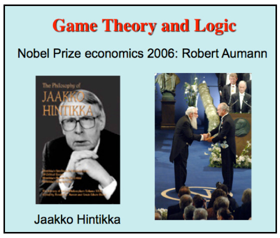




But the very same structure is also used, say, in the chapter on epistemic logic. We motivate the issues by means of simple informational scenarios concerning questions and answers that students immediately find appealing. Introducing a language with knowledge operators allows them to state significant things about the agents involved in a concise manner, and finding models for this language that match a given intuitive scenario is a non-trivial task. Thus, in other words, instead of translation drill, we now emphasize the *Art of Modeling*. Axiomatic systems such as modal S5 now stand for significant properties of knowledge, and making deductions may actually show surprising connections. Update is the way of solving puzzles like the Cards in a satisfying systematic, as discussed earlier. Mathematical theory includes again completeness, or, more ambitiously, it could include an introduction to bisimulation as equivalence of information or process models. In terms of further outlooks, epistemic logic is of course well-suited to discussing basic themes in philosophy (say, adding belief, and then discussing the surplus of real knowledge over belief) and even cognitive science, where interactive social 'Theory of Mind' is considered a typical human skill.

In a similar manner, we structure the next chapter on dynamic logic as a stream-lined version of the basic Hoare Calculus of structured programs and actions, and as a natural companion to the epistemic logic chapter for the purpose of describing information dynamics. These perspectives then come together once more in the chapter on games, along two lines: we give logic games for earlier tasks of formula evaluation or proof, and game logics as revealing basic structures in reasoning about, and inside, social interaction. We also show some mathematical background such as Zermelo's Theorem and broader connections with game theory.





As for the intended interdisciplinary range: our windows at the end of chapters include topics such as computational content of logics (say, satisfiability checking as computation), information and the internet, natural language (for instance, we use generalized quantifiers as a window after the syllogistic), cognitive science (the Wason Card Task and difficulties in actual reasoning, confronting logical systems with cognitive architecture as in natural logic), and history of logic in other cultures, especially in China. Finally, we keep emphasizing the value of the mathematical aspects of logic, none of which are meant to be endangered by this course: precision in formulation, abstraction, systematicity, and the beauty of meta-theory.

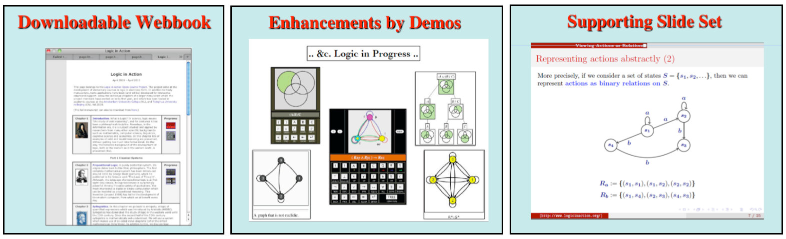
5 The spirit and the letter of the course

There are various ways of looking at this course. Our broad educational goal is to teach the students modern ideas and skills that they may find helpful in further academic professions or even beyond in society. We try to strike many chords in doing so. At a very basic level, we try to show that logic is fun, using classic puzzles as well as newer items such as Sudoku or the Cheryl Birthday Puzzle. It is just a simple fact that many people enjoy exercising logical thinking skills, and students are no exception. Next, we try to teach the students what we genuinely think are the core topics of the field: deduction, computation, information, and interaction, using a broadened set of topics that we hope will become standard. To us, an example like the Cards puzzle is as genuinely logical as worrying about Socrates' mortality. In addition, we try to convey an appealing picture of logic as a broad and live field that connects between many disciplines, or put more negatively: we try to combat widespread narrow exclusive views of logic by opening interdisciplinary and cross-cultural windows. In doing so, we also try to convey that logic still has a great future ahead of it, given that so much has kept happening over the last century. Finally, perhaps more silently, we also hope to convey a less utilitarian idea to the students: that logic has a cultural value in itself that enriches them.

These are the high-sounding ideals. In subsequent sections we will discuss what happens when these meet educational practice. But right here, let us also state another perspective, if you wish, 'the letter' of this course, that seems to be what remains on many colleagues' radar. Take away the above ideals, and just look at what has to be taught. One way of describing our curriculum is simply this: *we add modal logic* to the traditional topics of propositional and predicate logic. The reason for this description is that modal logic is indeed the technical core underlying our added chapters on epistemic and dynamic logic. While this mathematical formulation is an outrageously one-dimensional projection of what is in the course, and a misleading one in several ways, it does have the virtue of being short and intelligible. Moreover, since the connections of modal logic to classical systems are well-understood, the addition fits very well, so hard-bitten illusion-free teachers can just see this as their task.

6 The internet dimension

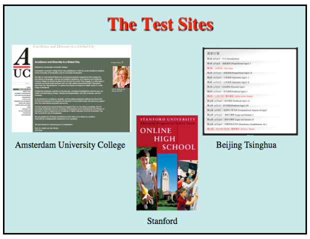
As stated at the start, the original impetus for making this course happen was an initiative toward creating free courses available on the internet, and supported by new technology. Our material is freely available on the website in the form of a printable textbook, slides that support teaching sessions, some videos, and exercises from various sources with answers.



Still, ambitions were much higher when the project started. We wanted to create a complete e-book with links to background material, applets for specific tasks or demonstrations, and open windows to the field of logic, from interfaces with automated deduction systems to more theoretical sources. A few chapters of this sort are indeed available on our website, drawing on the wonderful material developed by Jan Jaspars, a pioneer in computer-supported logic teaching in The Netherlands. Ideally, this electronic paradise would allow for complete self-study by users of the course, helped along by equally automated self-tests after chapters, without any interaction with human designers or teachers, except perhaps in the form of films or video clips. At a later stage, a more modest pilot version taught at Stanford was formatted for the EdX platform in a preliminary way. None of this has materialized so far, and we will discuss later on why this is so, and how much of a bad or good thing this is.

7 Experiences so far

This course has been taught since 2008 in various versions, all at an undergraduate level, at universities in Amsterdam, Beijing, Berkeley, Maynooth, Seville, and Stanford. Moreover, shorter versions have been taught elsewhere, including the 2011 ESSLLI Summer School in Ljubljana. An adapted version is also a standard part of the curriculum of the Stanford On-Line High School. This fits the intended range: from advanced high school level onward.



In what follows, we include a few statements from teachers about their teaching experiences, and student reactions. There has been no systematic pedagogical evaluation yet, which might have to involve a longer-term study of lasting effects qua skills and attitudes.

The texts that follow are still to be edited into a final version.
The passage will then not look like a set of advertisements,
but as a, much shorter, list of major experiences.

Dora Achourioti (Amsterdam University College). 'Logic in Action' is not a conventional logic textbook. The conventional way for an introduction to logic would be to teach the technical material first and then study its various applications (if applications are at all meant to be part of the picture). In LiA, logic rarely features in its own, that is, outside of the real life practices where it is most naturally embedded. For the teacher, this presents a challenge. The conventional road is straightforward. But this one is not clear how to follow. How do you make sure to reach the mathematical precision that you do not want to compromise? How do you make sure that by complementing the material on the technical side you do not thereby take away from the richness and breadth of the subject and its various connections with other disciplines as highlighted in the book? It is important to work with a text that allows questions to be asked and teaching to develop, rather than enforcing a rigorous attitude that leaves no room for flexibility and hence no room for improvement. At AUC we have tried to make the most out of this flexibility, using the book more as a rich source of inspiration, rather than a book of instructions on how to do logic.

Wes Holliday (University of California at Berkeley). The last time I taught with 'Logic in Action' was in Spring 2012 at Stanford. Nothing from that experience seems in conflict with any of the written impressions in this article. Since then I have used the Logic in Action text as my go-to recommendation for students in my modal logic course and my first-order metatheory course who want another text for review or to strengthen their understanding. (My text for modal logic is "Modal Logic for Open Minds", and my text for first-order metatheory last time was Chiswell and Hodges' "Mathematical Logic", plus selections from Enderton, van Dalen, and Hodges' "Elementary Predicate Logic.") Student evaluations have been very positive. My plan is that when I am assigned the introductory logic course at Berkeley (with about 100 students), I will use Logic in Action, and then I will have a lot more to say.

Tomohiro Hoshi (Stanford On-Line High School). The material that 'Logic in Action' provides matches the pedagogical spirit of the Stanford Online High School very well. We believe that active and live engagement of our students is essential for learning processes and have tried to represent this spirit in our online environment. We often feel that some of the most technologically advanced materials with lots of automated support for students do not fit the above goals. By contrast, 'Logic in Action' makes its material accessible to a wide variety of our students, not only by having the text and associated supplementary material free online, but also by grounding technical materials that are often challenging to students of our age groups to fields of study that they can more readily relate to, while still providing great opportunities for our students to experience what we believe is a true learning experience by "getting their hands dirty" with the material they are provided.

Fenrong Liu (Tsinghua University Beijing) I have used the textbook 'Logic in Action' at Tsinghua, for undergraduate teaching for several years now. It is a one semester course, 48 hours in total. I usually cover proposition logic, first order logic, epistemic logic and dynamic logic, and sometimes a bit of logic and games. The message of logic as a interdisciplinary subject is well received, this is also confirmed by the structure of the audience, as my students are from mathematics, computer science, philosophy, physiology, and engineering. The students found the traditional part of first order logic still rather difficult, but get very excited when we start epistemic logic and dynamic logic. They can easily connect what they learned in class with how they reason with information in real life.

8 From plan to reality: difficulties

In the confrontation of this new course with reality, several things can be noted. First, there is a big gap between a course taught at institutions by teachers interacting with students and a course for pure self-study. Quite simply put, apart from a few scattered reactions that we have received from people visiting our website, the second goal does not seem to have been realized at all. So let us consider more standard academic environments. Here, too, much can be noted that leads to serious questions about the intended set up as explained in the above. We list a litany of difficulties, though this does not mean *Logic in Action* is not appreciated!

One thing that is very noticeable is the immediate divergence in the way the course has been used, depending on the teachers' experiences, or their own views on the subject. It seems fair to say that *Logic in Action* has as many dialects as it has locations. One striking phenomenon is an urge to just add new material to old courses, retaining all the old topics such as natural deduction, so that the course loses its radical character, and becomes the addition of, say, some epistemic logic to a standard logic course. Two prominent dialects in this regard are as follows: teach a sequence 'propositional logic, modal logic (in a more formal style), first-order logic', or teach things in the order 'propositional logic, first-order logic, modal logic'.

There may be various reasons for this minimal modus operandi, in whatever order it is done. Perhaps teachers are happy with the standard material in logic introductions, but do not object to adding a few topics to round it out or make it more up to date. Some teachers have also complained that the course does not provide enough abstract mathematical material and training, which they consider the backbone of logic education: technique first, erudition and broad-mindedness later. Perhaps also, student audiences want more focus, finding the wide spread of topics disorienting. Living in a wide open world is not for everyone.

What may also be the case, and this is a perennial issue with introductory logic teaching, that broad audience courses do not work as well as specialized courses catering to the needs, and prejudices, of students from specific disciplines. Indeed, there may also be perceived bias in our material, despite the intended broad scope. Anecdotal responses to the course have been that it is too much computer science oriented, and too little toward, say, philosophy. Somewhat ironically, a traditional very formal skills-oriented logic course may generate less resistance from specific disciplines: since these skills do not apply to anything in particular, such a course treats everything equally, having no favorites. But it may also just be a fact that university students fall into very different categories. There are 'open-system types' who like flexibility and change, and 'closed-system types' that thrive only in well-defined communities with strict norms for what is 'good' and what is not. This division is definitely observable in graduate schools, where one has to cater for the sensitivities of both types of student – and it may well be that a course like this will rub closed-systems types exactly the wrong way.

Of course, there may also be simpler down to earth issues with teaching the material in its current form. One difficulty is finding good exercises that test understanding of new topics and new skills. Traditional logic courses have had at least a century of honing test questions in their main fare, while in a new course like this, we still need to find the right repertoire, say, to train and test students in understanding the working of questions and other informational acts. Likewise, the importance of our computational thread raises issues: should not this involve real training in programming or other hands-on computational skills? Some members of our team think so, and therefore the course materials include a Part IV with programming materials. However, other teachers find this emphasis alienating for students who want a general logic course, not one biased toward computer science.

As for the internet and technology aspects of the course when it started, our main experience has been that this is not a decisive factor in the success of the course as taught. It may be an asset for some students, but given the level of sophistication in the world of education today, a course like this does not offer any creative technology that would give it an advantage over any other. To get ahead in this race, presumably, huge development efforts would be needed. But it is very unclear right now what realistic and desirable goal would justify what effort.

Finally, returning to the idea of a self-study logic course with benefits for everyone, it seems clear by now that *Logic in Action* really functions as an upper-level high school or undergraduate-level university course, directed mostly toward logic in its scientific form. Clearly, one could also have the goal of improving actual thinking and argumentation practice, but this would require an effort that we have not made. And in fact, it is not clear that there can be a happy mixture of the abstract intellectual approach taken in this course and hands-on courses on argumentation theory or critical thinking. This is not to say that this would be an endeavor without value. Indeed, even famous traditional logicians had the ideal that logic could improve the level of argumentation and reasonable interaction in our society. But such an ambition would be a challenging separate further task.

9 Conclusion: where to go from here

Given the above observations, our current thinking has become more moderate and laissez-faire. It may not be a good idea to impose much ideological uniformity on a course like this, and in any case, enforcing it seems impossible in practice. Moreover, given the fast developments in the academic role of logic, flexibility is needed for further changes. The material for a broad logic curriculum in the style described above remains available in the on-line textbook, which will be updated periodically. In addition, we will add teaching tools as they come our way, including course slides and new exercises. We are also thinking of a best practices forum where users of the website can meet. Finally, we are thinking of 'teaching the teachers', offering courses at suitable venues for people considering to use this course.

As for the internet ambitions, by procrastinating, we have actually reached a useful phase where initial expectations about on-line courses have been downgraded to more realistic levels. The current trend toward 'blended learning' emphasizes the indispensable active role of teacher-student interactions, over and above whatever a textbook and website can give. When polled, students overwhelmingly prefer more teacher contact over slicker technology. Our material can help in this, but trying to 'can the course' will not work. We may consider creating a 'logic garden' (on the analogy of the 'math garden; http://www.rekentuin.nl/), i.e., a site where any visitors can experiment with the material presented here, leaving traces that we can use to improve our course, and learn more about what it is to learn logic.

The course *Logic in Action* was designed to enrich what students learn in their first encounter with logic. In addition to content of any introduction to a field, there is also a spirit: a modus operandi and even an intellectual value system gets transmitted. Ours would be to make the scope of logic broad, and in line with that, also the view of its position in the university arena. While we are not expecting a revolution, given our material and teaching experiences so far, we do believe in the power of small steps in creating large beneficial attitude changes.