Introducing Students to Logic

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By

Roderic A. Girle

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INTRODUCTION

This text is written for lecturers and tutors. It is not a students' textbook. It's about teaching students *Introduction to Formal Logic* in a Philosophy or Humanities context. It is based on the experience of teaching over 20,000 students during some 40 years at three universities, two in Australia and one in New Zealand. Students taught me a great deal. I also learned a great deal from being a student in the courses taught by the late Malcolm Rennie. Malcolm was a brilliant teacher who had the ability to make the most complex seem simple.

At the University of Auckland there was a one day seminar for staff to learn about the standard New Zealand secondary school syllabus. The day began with a talk about first year experience. I do not remember the date or the name of the keynote speaker. But the talk was very enlightening. As I listened I realised that much of what was presented was highly compatible with the way in which Logic was being taught in the Philosophy Department under my supervision. The focus of the keynote address was on students and their experience of Universities in Australasia.

In what follows a great deal is owed to that keynote address. The emphasis is on *students* and *introducing*. Students are front and centre. Novice students are the students that feature, new to University, new to Logic. And most of them new to Philosophy.

This book is in seven Parts and has four Appendices.

Part I is intended to encourage lecturers to think about a variety of general issues concerning *students*, and *content*, and the *integration* of lectures, tutorials, assessment, texts, and online resources. It is focused on the basis on which to develop student understanding and skills.

Part II is about introducing students to Propositional Logic (**PL**) and the use of **PL** for analysing and evaluating premise-conclusion arguments. It begins with material about ordinary language and premise-conclusion arguments expressed in ordinary language. Then the introduction of formal **PL**. The focus is on developing student knowledge of and skills in working with **PL**.

Part III is about introducing students to Monadic Predicate Logic (**MPL**). **MPL** is introduced by building on students' knowledge of and skills in working with **PL**.

Part IV is concerned with extending students' knowledge of and skills working with **MPL** to knowledge of and skills working with General Predicate Logic (**GPL**).

Part V is about optional extra topics that might be taught in the course. The topics are **GPL** with Identity (**GPL=**), Syllogistic, the Theory of Dyadic Relations, and descriptive singular terms.

Part VI is concerned with the Assessment of students' knowledge of and skills with **GPL=**.

Part VII contains some comments about distance education, online teaching, and Computer Assisted Learning (CAL).

There are four Appendices:

Appendix A contains Sample Worksheets for Propositional Logic.

Appendix B contains an account of the List Method for implementing Semantic Tableau.

Appendix C contains a Sample First Test with answers and a marking guide.

Appendix D contains compacted Sample Second and Third tests.

This text is *not* about teaching either Critical Thinking, or Philosophical Logic, or Metalogic, or Argumentation Theory. The focus is on teaching students basic first-order formal logic and its application to the evaluation of premise-conclusion arguments from everyday discussion and argumentation.

There is a tradition of teaching a mixture of Critical Thinking and Formal Logic as in the many editions of the classic texts of Irving Copi *et al*. (the most recent manifestation is: Copi, I. M, Cohen, C. and McMahon, K. (1999) *Introduction to Logic*, Public Domain Mark 1.0). Courses based on such texts require far more time than the single semester of 12 to 14 weeks with 24 to 26 lectures available in Australasia. So this text addresses the teaching of just Formal Logic. Critical Thinking is taught separately in most Australasian universities.

In what follows the term "course" means a series of lectures or their equivalent taken to be a whole unit of study for one semester of 12 to 14 weeks. Some universities use the term "subject" or "class" or "paper" (as in "read a paper").

Ideas are forwarded mostly on the experience of teaching *Introduction to Logic* to over twenty thousand students during some thirty years or so at three universities in Australia and New Zealand, and partly on the basis of research into the experience of first year university students in Australia.

There is one caveat. The material about students could be misleading if it's taken to apply in detail everywhere on the planet. It is not so intended. Its detail applies to Australasia. But the headings might prompt lecturers

elsewhere to do some research into the situation of their first year students and reflect on what that means for their approach to introducing students to formal logic, and dare I say, to teaching some other courses as well.

From time to time there will be Anecdotal material culled from experience. This will be marked as such. Sometimes it will run counter to general assumptions I have encountered. Sometimes it will illustrate a point.

Lecturers should also reflect on whether they are being effective in teaching logic. This guide is not for those whose approach is "take it or leave it" but for those who wonder whether they are being effective teachers. If the enrolments in the course are, for example, an official 120 before semester begins, but have shrunk to 80 by the end of the second week of semester then it is at least worth asking the question, "Why have students left this course?" Answers that denigrate students will never be helpful.

There are various measures of successful teaching. One objective measure is the number of enrolments. They are indicative but not conclusive. In a stable overall university course structure the enrolments provide a reasonably good measure. If the University is steadily expanding and if course structures remain constant, then it is reasonable to expect logic enrolments to expand at the same rate. For example, if enrolment in an *Introduction to Logic* course is 250 a year when the University has 20,000 students, then if the University expands to 40,000 students and course structures are constant, then one would expect the course numbers to expand to at least 500. If enrolments remain at 250 then there should be some analysis of why the numbers have not increased. There are lots of legitimate reasons why there might be no increase, but the lack of any increase needs to be understood. If the enrolments decrease to 120 then that should be of considerable concern.

Enrolment numbers do not mean much in the context of substantial structural course changes at the overall University level. After the academic environment settles down into a new pattern, then enrolments and their increase or decrease or constancy begin to mean something.

One underlying question for lecturers is, "Why have students do this that way?" Philosophers in particular must do what they say, "Think about it." To do otherwise could result in the teaching of logic being swept away from Philosophy and the Humanities. Furthermore, academics need to think about their responsibility for the employment of postgraduate students after they graduate. If the Philosophy Department/Discipline/ Project is shrinking while the number of postgraduate students is increasing, then the question is, "Are these students expecting to find

positions in academia?" If they are, then presiding over shrinking opportunities is not helpful, but might even be considered irresponsible.

Teaching counts for very little in the International Competition for University academic status in the early 21st Century. Research is what counts in the early 21st Century. In that context it is understandable, but unfortunate to say the least, that some lecturers could not care less about undergraduate student education. For those who are concerned for undergraduate students and their education, I hope this text will be of some help. For the rest, I hope your Research Grant applications are successful.

In Australasia research funds come mostly from external bodies by way of research grants. Some academics use research grants to "buy out" of teaching. There are few if any ways of "buying out" of research. When an experienced lecturer buys out of teaching they are often replaced by an inexperienced post-graduate student or by a temporary junior lecturer. The replacements are often hired on a casual basis. The consequences of this trend are difficult to predict, but it's not unreasonable to think that the quality of teaching will deteriorate. It is hoped that inexperienced lecturers might find this text helpful.

This text is offered as a source of advice for those who teach in a mainly face to face teaching environment, if logic is still offered in their philosophy or humanities program. But there are some comments in a short final Part about Computer Aided Learning (CAL), distance education, and online teaching.

PART I

GENERAL MATTERS: STUDENTS, CONTENT, EDUCATION

CHAPTER ONE

STUDENTS

Without students there are no *Introduction to Logic* courses. Lecturers who have some idea about the background, situation, and motivation of their students are more likely to be better at engaging student interest and keeping it alive over the length of a course than those who have no idea at all about the students they teach. This is not to deny that some lecturers are born to the task and seem to need no coaching whatsoever. But even such naturally gifted lecturers might learn something from this text.

In this Chapter I introduce six matters that are relevant to understanding students from an academic point of view. The first is the relevant educational background of students. The second is about students as off campus students. The third is about a student's relationship to the university as a community. The fourth is about a student's study and time spent on courses. The fifth is about a student's professional relationship with lecturers and tutors. The sixth is about the way in which university structures impact on students' motivation and choice of courses such as *Introduction to Logic*.

The following comments about student matters are based on research and on the author's experience in the Australasian tertiary and secondary educational environment. That experience includes the design of syllabus for teaching logic in Secondary Schools in the Australian State of Queensland. Characteristics of students in other places may well be quite different. But the headings could be exactly the same. Fill them in for your situation.

1.1 Logic novices

Nearly all students in *Introduction to Logic* courses are complete *logic novices*. In some places there might be a tiny minority of students who have studied logic in secondary school, or have met some logic in a mathematics course, but the vast majority will not.

An *Introduction to Logic* course should be kept as simple as possible since the students are complete novices. If the course is too difficult for a novice, then the novice leaves, or stays but spends little time on the course and gambles on gaining a pass grade. They will just hope, to borrow a phrase, "that the Force will be with them."

Most novice students know little about the central idea of an *argument* as making a case for a point by giving reasons, rather than by appealing to feelings and goals and conceptual associations in order to justify the point they are making. Some students might have taken a course in which there was some critical thinking material. Those few might have some understanding of making a case with reasons (premises) and a point (conclusion). In many cases it will be quite a strange idea. Further rather trenchant discussion is found in Richards. (Richards, T.J. 1979, "Attitudes to Reasoning", *Australian Logic Teachers Journal*, 4.1, pp 1-11)

> *Anecdote*: At the University of Auckland the Student Union used to produce a course review manual. One year their account of *Introduction to Logic* was that the course would give student a *completely new way* of looking at argument. (my emphasis)

If anything, novice students might have the idea of logic as reasoning or problem solving. This guide is not about reasoning, nor is it about the problem solving approach to logic. It's not about the mental activity of reasoning because it's about the analysis of premise-conclusion argument couched in ordinary language, not the psychology of reasoning.

A problem solving approach is presented in Barwise and Etchemendy. (Barwise, Jon and Etchemendy, John, 2001, *Computers, visualization, and the nature of reasoning*, academia.com) Problem solving is certainly a worthwhile way of approaching logic. If you are interested in that approach then you might want to read to the end of this section about students and then read Barwise and Etchemendy. It's a very interesting approach, but it is not followed here.

Finally, lecturers should pitch lectures and other material at the *average* novice student. Don't be misled into thinking that the bright enthusiastic students who talk with you at the end of lectures represent the average. Well planned assessment will tell a lecturer about the average student.

1.2 Work at home

21st Century first year students in Australasia mostly live at home. But there is a substantial minority, consisting mainly of either students from

regional towns or students from other countries, who live in university residences or residential colleges or apartments on or near the campus. But the great majority live at home and spend as little time as possible on campus. Once upon a time students used to come to campus not only to attend lectures and tutorials. They would also engage in all sorts of student activities. That's no longer the case. Nowadays the majority of students come to campus, if at all, to attend a lecture or a tutorial and then leave.

Work at home students need materials that will give quick feedback. Texts without exercises are useless. Texts with exercises but neither answers nor solutions are next to useless for a novice. If a lecturer decides that a text is excellent but has no answers or solutions, then they should write a comprehensive set of answers and/or solutions for that text and make it available for students. Fast feedback is vital.

If the lecturer is willing to respond to email then students who have coursework problems will often send email about problems they are having with the course material. They are more likely to be average students. Their email should be treated seriously. Email provides an opportunity for fast feedback, and for the lecturer to think about whether they have been clear about the topic with which the student is having problems. Students are not the only ones who might be having problems in *Introduction to Logic.* Lecturers and tutors might also be having problems teaching a particular topic.

Universities have begun to put more and more course material online with recorded lectures and software presentations. In what follows "PowerPoint" will be treated as a term referring to all such presentations. Many students don't come on campus to lectures at all. Some universities have begun to poll lecture attendance and allocate lecture theatres according to attendance rather than according to enrolment. At least one Australian University has abandoned all face to face lectures (The Sunshine Coast University). Some tutorials are now conducted online by means of meeting software such as Zoom or Teams or Meet. In some cases student consultation has moved to email or video meeting. This began years before the 2019 pandemic crisis. The pandemic crisis accelerated the move to online teaching.

> *Anecdote:* In New Zealand there was a TV advertisement for a major ISP that encouraged students to record lectures and take pictures of on-screen material and then contact staff for help via mobile phone. Suddenly in the early years after the turn of the century I started to get emails from students containing pics of their truth-trees with questions about their work. No worries. But I did announce in class that I would

not answer within minutes email received after 10:00 p.m. The students laughed. They knew I was not really telling the truth. But the point is that they had begun to become online students and sought consultation and help via email, not by meeting me in my office during the day. They were looking for quick feedback.

Teaching online is not the same as face to face teaching. Many academics think that online teaching is just a matter of recording lectures and PowerPoint presentations. That is simply not so. There is a discussion of this later.

1.3 Campus Social Life

Research shows that nearly all first year students residing at home make no new friends in first year at university. That does not mean they are friendless, quite the contrary. They continue with their Secondary School friends and social life. So there is no social pressure to come to the campus to engage in social activities and meet new friends.

Given that most full-time students are taking eight courses over a year, for example, four for each of two semesters, then that set of eight is highly likely to be unique to that student. This applies especially for students in an Arts Faculty or a general Science Faculty. If students do come to campus then it's highly likely that they will see a different set of students in each course's lectures. This contributes to social indifference with respect to the university community, but not with respect to their continued Secondary School social life.

This is reflected in many ways. Students will often choose courses that reduce their time on campus. If they *must* come to campus for tutorials or practical classes, for example, then they may well choose courses that minimise the number of days they must come to campus, or choose courses that do not demand compulsory attendance at tutorials or practical classes. The final student decision to take *Introduction to Logic* might be for reasons of time-table and minimising coming to campus, not especially for reasons of academic interest in logic.

There is the exception in the case of overseas and regional residential students. Overseas students are often those for whom English is a second language, ESL (English Second Language) students. Provision should be made for overseas students in terms of advice and help. There will be more comment on ESL students in the section on teaching practice.

1.4 Deadlines drive study

Research shows that students work to test and assignment *deadlines*. Students take little notice of unrealistic advice about managing their time, especially advice such as spending equal time each week on each of four courses. Attempts to force students to follow certain study practices by means of compulsory weekly assignments may well drive them away.

The due dates of assessment items drive study. If a student takes four courses for a twelve to fifteen week semester, then the equivalent of three or so full-time weeks will be spent on each course. If there are three assessment items then there will be one week preparing for each test or writing each assignment and a total of three weeks will be spent on concentrated study for the course. If two assessment items are set, then two weeks will be spent on the course and extra time given to other more demanding courses. So, in theory, each student has one assessment item due for each week of semester across four courses. Some even say, "I do the test and then deliberately forget that course because of the other assignments."

If assignments and tests are not given reasonable values, then students will look for other courses for value. Those lecturers who act as if their course should be given 100% of student attention will drive average students away, unless the course is compulsory. *Introduction to Logic* is rarely compulsory.

Many academics have observed that students are over-assessed. But reducing assessment in the course they teach, just means that students spend less time on that course. Over-assessment is a structural issue for the university as a whole. It cannot be corrected at the level of a single course. Good luck with trying to change assessment practice at the overall university level.

When students sign in for a course their priority questions are mostly directed towards assessment: When is the first deadline in this course? How many tests/assignments are there and when are they due? How much are they worth? Is there a final exam? What topics will be assessed? Are there sample papers with answers and marking schemes, or assignment exemplars with comments? If these priority questions are dismissed as unimportant students will leave the course.

Students look for courses that they think they will be able to cope with. If a lecturer makes the assessment difficult, then if the course is not required, students will leave the course. The word goes round via social media. Above all, the assessment scheme must be transparent because students need to know what they have to do.

1.5 The unnamed lecturer and tutor

Research shows that most novice students do not know the name of their lecturer or tutor. The lecturer will be known by a description such as "the older woman who wears flat sandals" or "the tall bloke with a beard who never answers email" or even "that hot chick" or "that cool guy." Students remember and exchange information about what they see as positive and negative attributes.

So there is a detachment of lecturers and tutors from students. This is addressed later in the section on teaching. This can be ameliorated slightly, but only slightly, if a lecturer uses presentation software or overhead transparencies by having the same footer for each slide with the lecturer's name, discipline and email. If students do not know the lecturer's name then they will be unable to find the lecturer's office to get help and advice. Email becomes very important.

1.6 Academic structures and teaching

Students work in a structured university environment. Each university is different. For example, some have a rigid structure of prerequisite courses as at the University of Auckland, some do not. The University of Queensland with over 70,000 students has no prerequisite structure at all. Nor does the University of Queensland prevent students from enrolling in courses that have the same lecture times. Students have to check it all out for themselves and fit into what is required of them.

> *Anecdote:* An *Introduction to Logic* course *might* fill a structural requirement. That is good as far as it goes. But there is a salutary example from the University of Auckland. Students at the University of Auckland were once required to take an Arts Faculty elective. This demand was made for many years and became so standard that staff and students took it for granted. Many students from Faculties other than Arts chose *Introduction to Logic* as their Arts elective. So the majority of students were in the class not because of pure academic interest, but because they were satisfying a regulatory demand. This pressure on students was partly responsible for larger and larger logic classes. There were three semesters each year: a short six week intensive summer semester, and the two 'normal' twelve week semesters. The logic enrolments went up gradually over two decades until they reached 1700 students a year. This changed suddenly.

> The requirement to take an Arts elective was brought to a very swift end in the second decade of the 21st Century when the University of Auckland made substantial changes to course structures across every faculty of the university. The substantial changes de-listed both *Introduction to Logic* and *Introduction to Philosophy* from the list of elective options. Enrolments in *Introduction to Logic* changed dramatically with a loss of nearly two thirds of the enrolments. But not all was gloom for Philosophy. *Critical Thinking* was on the list of universally available courses in the new structure. Enrolments multiplied by over five times to approximately three thousand a year. Then yet another new structure was introduced and the STEM fad came to the fore. Most Arts Faculty departments failed to adapt and enrolments were severely reduced.

What does this all mean for teaching? It means that when you look at an *Introduction to Logic* class you are looking at students for whom the university's rules and structures are overwhelmingly important. There are many reasons why students enrol. They may be there to satisfy regulatory demands, or there because of other things such as curiosity, or there because of suggestions in philosophy or mathematics or computer science courses, or because of what other students have told them, or because of what the university student organisation has put in its course survey, or just because the course is *convenient*. Never underestimate convenience.

> *Anecdote:* When *Introduction to Logic* numbers were very high at the University of Auckland there were two streams of lectures in the 12 week semesters. The lecturer gave the same lecture twice on the same day. The smaller stream was at 8:00 a.m. About 180 students attended. One member of the lecturing team found the early morning time to be very difficult. So it was decided to get some indication of what would happen if the class were to be scheduled at 9:00 a.m. or 10:00 a.m. A poll of the class showed that nearly all of the class would stop taking *Introduction to Logic* if it were not offered at 8:00 a.m.
>
> The class's student representative explained that many students living at home in the suburbs arrived early at university because of travel issues, and looked for a class at 8:00 a.m. *Introduction to Logic* was *convenient*.
>
> Change the time and lose 180 students in each 12 week semester. That's a total loss of 360 students each year.

All this means that lecturers may well benefit from a survey of students a couple of years after any structural change to find out what ‘now’ brings them into the logic class. There are bound to be surprises.

CHAPTER TWO

FORMAL LOGIC COURSE CONTENT

The core content addressed in this guide is classical First Order Logic or General Predicate Logic (**GPL**) and its application to the evaluation of premise-conclusion arguments. The term 'logic' in what follows will mean either 'formal logic' or 'symbolic logic', but mostly 'classical First Order Logic' It is assumed that the lecturer is either competent in **GPL** (or can fake it).

The content of an *Introduction to Logic* course in this text has two facets. One is the *logical system*, **GPL**. The other is the *application* of **GPL** to evaluate premise-conclusion arguments couched in ordinary language. The application of **GPL** is usually the main rationale given by academic philosophers when asked about why they support the teaching of logic in their philosophy department/school/discipline/project. The use here of the hyphenated "premise-conclusion" is to draw attention to the narrow scope of the application of **GPL** in the broader context of argumentation analysis (see van Eemeren, Frans H., Grootendorst, Rob., Snoek Henkemans, Francisca. 1996, *Fundamentals of Argumentation Theory*, Lawrence Erlbaum, Mahwah, New Jersey).

I might as well declare that I think that the most general approach to argument analysis should be based on argument in the popular sense, that is, interactive civilised disputation and discussion. Disputation and discussion are a sub-set of multi-agent dialogue. Despite disputation being summarily dismissed in many introductory logic texts, one feature of disputation is the questioning of asserted propositions by asking for *reasons* or *evidence*. If reasons are given, then the reasons can be seen as the *premises* of a premise-conclusion argument and the proposition questioned is then seen as the *conclusion* of the premise-conclusion argument. It is this part of disputation to which most formal logic gives attention. In popular terms: *Do the reasons really substantiate the conclusion or the point being made?*

Most introductory logic texts use examples that are taken out of disputational or explanatory or information seeking multi-agent contexts.

Examples are presented as extended monological text. Reasons and conclusions need to be detected, and that is not always as easy as might be thought. Students often seize on the proposition they consider to be the most important and then say it is the conclusion when, in fact, it is a premise. Once the premise-conclusion argument is properly discovered, then it is evaluated. This is where logic in the form of **GPL** appears as an *evaluation tool*. So *Introduction to Logic* is an introduction to *applied* **GPL**, **GPL** applied to the evaluation of ordinary language premise-conclusion arguments. The deeply mathematical origins of **GPL** are deliberately ignored.

Having made the point about the focus on premise-conclusion argumentation, in what follows the complex term "premise-conclusion argument" will often, as in many texts, be shortened for just "argument".

There are five steps in the application of **GPL**. First there is *discovering* premise-conclusion arguments in ordinary language. Second there is *preparation* for translation of ordinary language to **GPL**. Third is *translating* from ordinary language to the artificial language of **GPL**. Fourth is the *evaluation* in **GPL** of the translated argument. Fifth is the transfer of the evaluation of the **GPL** translation to the ordinary language premise-conclusion argument from which the analysis originated.

This five step process is the subject of continuous controversy. Some academics believe that *Introduction to Logic* students should be made aware of the controversy. I do not. To make them aware would be analogous to introducing Year 1 and Year 2 arithmetic students in primary school to questions about the nature of numbers and how we know them.

2.1 Discovering premise-conclusion arguments

Basic to the discovering of premise-conclusion arguments is the understanding of the variety of things expressed in ordinary language; propositions, questions, commands, wishes, exclamations, promises, vows and namings, etc. Many students have not been taught in school the distinction between indicative, interrogative, imperative, optative, exclamatory, and so on. The distinction between active and passive voice is hardly ever taught. Bizarre as it might seem to some readers, I discovered that many students did not understand that the two sentences, "Sue loves Bill." and "Bill is loved by Sue." are different sentences expressing the same proposition. When first I said that one sentence was in active voice and the other passive, many students had no idea what I was talking about. So *I changed* to saying that one had three words and the other five – that's what made the difference.

Secondary School teachers of Logic in Queensland schools pointed out in weekend workshops that their main task was, as they called it, "remedial English". This issue might not exist at all in classes elsewhere, but lecturers need to know just how much they need to teach about English that will facilitate premise-conclusion argument detection. Some minimum amount of simple distinctions will almost certainly have to be taught.

Most examples of arguments in text books are highly 'domesticated' examples for students to analyse. The examples are highly propositional. So it's a matter of students being shown how first to detect the conclusion in the example. Students will often see one proposition to be the most important in the example, and think it to be the conclusion. But it is in fact a premise. Maybe it asserts some important general principle. So conclusion indicating words and phrases have to be emphasised. The rest of the example can then be taken to contain premises, including the important principle some thought was the conclusion. All of this is done in ordinary language, before translation.

2.2 Translating premise-conclusion arguments

Once the argument is detected and divided into premises and conclusion, then translation into the formal logic. Above all, do not begin by telling students that translation is incredibly difficult. That's bound to drive them away. Just get on with translating. Do not make this more complex than need be. Start with simple examples.

Some philosophers of logic see translation as formalising or symbolising or revealing the logical structure of ordinary language. Others see Logic, with a capital "L", as being an ontological and metaphysical study of central philosophical importance. Controversy continually simmers about these issues.

But, for practical purposes, it just does not matter for *Introduction to Logic* students. Whatever one thinks about the complex relationship between ordinary language, context, the world, and the artificial language of **GPL**, the *students* have to deal with that relationship at a workface of discovering, preparing, translating, and evaluating in **GPL**. Distracting *Introduction to Logic* students with complex philosophical controversy will almost certainly confuse them. If they are confused and distracted, then they will be less able to apply **GPL** to premise-conclusion argument analysis and evaluation.

Lecturers should adopt a self-denying ordinance, and focus on the practicalities faced by students, not on their own high level research interests and fine distinctions. If a lecturer thinks that the whole enterprise

is useless or unreliable, then they should think seriously about handing the teaching over to someone else.

Pedagogy should not be confused with foundations. Introductory courses for novices should be kept as simple as possible.

> *Anecdote*: Although some readers might bridle at what's just been said let me describe a very indicative experience at the University of Auckland. One semester it was decided to institute a special voluntary weekly discussion seminar for *Introduction to Logic* students interested in discussing philosophical issues about logic, including problems with language and logic, ambiguity, reasoning, the material conditional, and so on. The philosophical logic discussion tutorial was advertised with lots of encouragement and suggested topics. The enrolment that semester was about 500.
> **Not one student** came to that philosophical logic discussion group, not one.

The general approach to the logic system in this text is that there is an artificial language on which classical **GPL** is built. The language is a language of formulas that are assembled by recursive definition out of a set of symbols and letters. It is a language, as Gabbay and Woods say, "no one speaks, or could [speak]." (Gabbay, Dov M., and Woods, J., 2003, *Agenda Relevance: A Study in Formal Pragmatics*, Elsevier, Amsterdam, p 4)

Students should learn the business of translating into the formal notation, much as they would learn to translate into a foreign language. They should also learn about translating from the formal notation into ordinary language. These processes rely on developing *skills*.

After the students have a solid translation foundation, then they can be introduced to the "grammar" of the language they have been using. The grammar is the formal recursive definition of formulas and how formulas can be assembled from the symbols according to the definitions. Many lecturers skip the grammar of **GPL** and rely on student skill and intuition.

2.3 Evaluating the translation as Valid or Invalid

Various evaluation systems of **GPL** are used to evaluate translated arguments as *Valid* or *Invalid*. Systems are also used to divide the formulas of the artificial language into sub-sets such as tautologies, theorems, contingencies, and contradictions.

GPL is usually divided into propositional and predicate logic for the purposes of teaching. That division will be followed here.

Whatever the motivations and intentions of those who developed classical **GPL** over the course of history, the finished product stands independent of its history. The history is fascinating, but the structure and meaning of the final outcome is not determined by its history, even though its history will often illuminate the understanding of **GPL**. Structure and meaning are determined by the recursive definitions of the formulas, the proof system and the truth-value semantics of today.

GPL, like geometry, stands on its own artificially defined feet. By comparison, Euclid's geometry was probably motivated partly for making sailing safer and easier in the Mediterranean Sea, and partly for the building industry. But these motivations are hardly ever mentioned when students are taught geometry. A student does not need to know anything about either navigation or building to study geometry. Geometry stands alone in its own right. Just so, **GPL** stands alone in its own right. Its *application* is important.

This guide will trample on various hobby horses and some will find it simplistic and irritating. Tough!

There is one other matter concerning content. It's non-classical logic and unorthodox semantics and proof systems. If the content of a course is to be logically unorthodox, then the students who qualify will not have the generally academically expected knowledge of students who have studied *Introduction to Logic* in a philosophy department/school/discipline. Orthodox or not is not always an easy distinction

For example: one interesting non-orthodox approach to the content of predicate logic is found in Hodges' very interesting text (Hodges, W. 1977, *Logic*, Penguin Books, Harmondsworth, England). Hodges begins predicate logic with individual constants and identity. So his text has **GPL** *plus identity* in the core content. That is not unorthodox. It's a pedagogic difference. The important departure in logic itself is otherwise. The orthodox semantics for **GPL** is based on a non-empty universe of quantification. Predicates can be empty, but not the universe. By contrast, Hodges' semantics allow for an empty universe. So the semantics are not orthodox. The predicate logic is not orthodox.

In teaching *Introduction to Logic* I decided to be orthodox, and not use Hodges. But Hodges' text is certainly worth reading. It has interesting things to say to a logic lecturer, not only about predicate logic but also about semantic tableau.

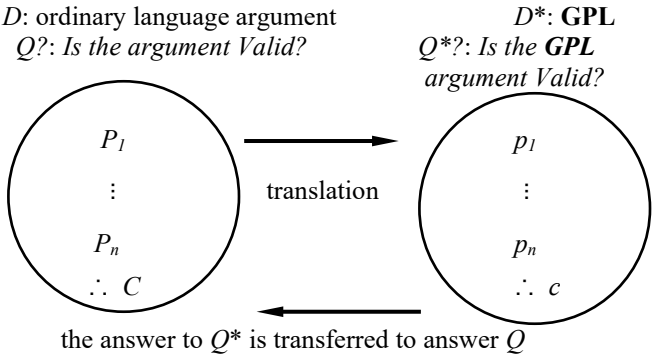
Some other un-orthodox approaches are more deeply different. They are based on non-classical logic. This is a matter for lecturers to decide.

Whatever the formal system, there are still the same five steps leading to evaluation.

One general underpinning schematic for the practical use of **GPL** is to be found in Gabbay and Woods' *Can Do Principle* (Gabbay, Dov. M. and Woods, John. 2003, *Agenda Relevance: A Study in Formal Pragmatics*, Elsevier, Amsterdam, p. 49):

> *Can Do Principle* bids an investigator of a question Q in a domain D to invest his resources in answering questions Q_1*, ... , Q_n* from domain D* when the following conditions appear to have been met. First, the investigator is adept at answering the Q_i* and second, he is prepared to attest that answering the Q_i* facilitates the answering of the initial question Q.

In diagrammatic form the principle has the diagram below as one instantiation. When the principle is applied to premise-conclusion ordinary language arguments, the domain, D, is ordinary language argumentation. More specifically, it is the domain of premise-conclusion argumentation. The question Q is: *Is the argument valid or invalid?*



Not everyone would agree with the Gabbay and Woods' account as instantiated in the diagram above. Nonetheless, it is used as basic for this text. It is one possible basis for the lecturer's teaching. For the practical purposes of teaching the content of *Introduction to Logic* the diagram needs to be enriched. This extra depth will be discussed later in the section on teaching.

If the reader has some other idea, then think it through, write it down and use it as a basis for *teaching* the application of **GPL** to arguments.

Remember it has to be applied to teaching novice *Introduction to Logic* students.

It is worth noting that the *Can Do Principle* is also a guide for the discussion of the *reliability* of the evaluation produced in the right domain, *D**, as an evaluation of the argument in the left domain, *D*. That discussion can be introduced to students, but as far as I know there are only two texts among dozens and dozens that broach the matter of reliability in any systematic way. Reliability is usually passed by and not seen as a part of the core content of *Introduction to Logic*. Reliability is often discussed in advanced logic courses. Lack of reliability is widely used in one form or another as a motivation for developing non-classical logic.

There are two general approaches to the evaluation of translated arguments: *semantic* and *proof theoretic*.

2.3.1 Semantic systems: truth-tables and truth-trees

Truth-tables are used in a semantic evaluation system for propositional logic (**PL**). It is usual to begin with truth-tables in **PL**.

Evaluation is based on definitions of Valid and Invalid. Providing definitions and students' learning them is one thing. Students' applying the definitions to truth-tables is another thing.

It is a mistake to assume that students will read the definitions and somehow, even automatically, apply them correctly. Students have to be *taught how to apply* definitions. We return to this in the later section on teaching. Sometimes the definition of *soundness* is introduced. That is, an argument is sound when it is Valid and the premises are true as a matter of fact.

After students are introduced to truth-tables it soon becomes clear that truth-tables are limited by the practicalities of size. A sixteen row table is very much at the practical limit. A thirty two row table is at the very limit. So other evaluation methods are introduced.

They either extend semantics or introduce a proof system. The semantic approach is to extend truth-tables by *truth-trees* or *semantic tableaux*. Truth-trees will show whether an argument is Valid or not. If not Valid the truth-tree will provide a counter-example that shows the argument to be Invalid.

The emphasis in truth-trees is on *semantic counter-examples*. Truth-trees can be seen as a means of *searching* for counter-examples, or, as Hodges points out, a search for inconsistency. Truth-trees have the advantage of being a two edged sword. If the translated argument turns out

to be Valid then a closed truth-tree will be generated. If the argument is Invalid an open truth-tree will provide a counter-example.

We return to this in more detail below.
We now turn briefly to the standard alternative to semantic methods.

2.3.2 Proof systems: natural deduction

The proof method is usually introduced by means of a system of *natural deduction*.

Natural deduction is often presented by many lecturers, if not most lectures and texts, as the main evaluation mechanism for both propositional and predicate logic. There is even an axiomatic proof system in at least one introductory text. Students need to develop a range of skills and strategies to deal with and learn how to construct proofs.

There is an issue with counter-examples in natural deduction. Counter-examples have to be generated separately from the proof system. Students have to learn a second set of skills in order to develop and test counter-examples. Since a considerable amount of philosophical debate uses the method of counter-examples, it would be unwise not to have substantial material about counter-examples in an *Introduction to Logic* course taught in a philosophy department.

Some lecturers and texts cover both natural deduction and truth-trees for *Introduction to Logic*.

> *Anecdote*: Experience at both the University of Queensland and the University of Auckland showed that teaching both natural deduction and truth-trees in the one introductory course of 26 or 24 lectures led to considerable student confusion. There did not seem to be any way to untangle the confusion. In Auckland the *Introduction to Logic* course reverted to a truth-tree only course, and one of the Stage 2 logic courses contained a full course of natural deduction.

Because some students have cognitive issues with pictorial and diagram methods, and because truth-trees are semi-diagrammatic, there are other ways of representing semantic tableau. One is the little known *list method*. It is used to great effect with theorem provers coded in PROLOG. (Fitting, Melvin (1996). *First-Order Logic and Automated Theorem Proving* (2nd ed.). Springer) The list method is a semantic tableau method without diagrams and is set out in Appendix B.

2.4 Extending beyond GPL

The content of an *Introduction to Logic* course might be extended beyond basic **GPL** to include identity and/or the theory of dyadic relations and/or some set theory. Sometimes *Introduction to Logic* courses also include traditional syllogistic as a way of introducing predicate logic, or even as a way of introducing logic. Neither of these approaches is recommended here. Traditional syllogistic, identity, and theory of relations are considered in this guide to be extra or supplementary topics for an *Introduction to Logic* course. Whether they are included will probably depend on a realistic assessment of the hours and weeks of teaching available.

There are many courses on offer at universities around the world and some in a few secondary school systems in which the content of *Introduction to Logic* adds some Critical Thinking to **GPL**. It's difficult to include such topics in the time available for an *Introduction to Logic* course in most Australasian universities. *Critical Thinking* is usually offered as a separate course. Syllogistic is sometimes added as topic of interest in itself. That separate topic is not included in this volume. Sometimes syllogistic is used as a way of introducing predicate logic. There will be discussion of the difficulties of introducing students to predicate logic in Part III.

> *Anecdotal:* Most mathematicians and computer scientists with whom I have had discussions about teaching logic have shown that their reason for teaching **GPL** has little or nothing to do with applying it to evaluate ordinary language argument. Their interests have been focused on the formal system itself and the properties of the system and its relation to mathematics. Their focus is metalogical or incestuously formal.
> They mention completeness and soundness and Gödel's theorems. Sometimes they are puzzled about why students complete an *Introduction to Logic* course in philosophy with no knowledge of these meta-theoretic matters. They often dismissed the talk of the application to ordinary language argument as a trivial matter that can be dealt with, if at all, 'by the way'.

Having looked at student matters and content matters, we now turn to the details of teaching students the content, bringing the two together.