Is lecture attendance just a flip of a coin?

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BACKGROUND
In the sciences, the content of sequential lectures is often planned under the assumption that the majority of students present in the class have attended the previous sessions. To some extent, students are expected to be able to recall and understand the previously delivered content. During a study into the effectiveness of a novel lecture engagement strategy (Interactive Lecture Demonstrations, or ILDs) in a first-year introductory electronics unit (Mazzolini, Daniel, & Edwards, 2012), student-generated codes were used to anonymously track individual students' responses to the ILD activities over successive lecture sessions. These codes offered an unintended proxy for attendance, with surprising results.

PURPOSE
To what extent can lecturers assume that the same set of students attend each lecture, and therefore construct a lecture sequence that builds lecture-by-lecture on previous work?

DESIGN/METHOD
To enable anonymous tracking of student responses over multiple lecture sessions, students were prompted with a set of 5 questions to generate an anonymous but unique identifying numerical code at the start of each session. For example, one of the prompt questions used was "what is the last digit of your postcode?". These codes, along with other student responses, were electronically submitted using audience response devices (i.e. clickers). By comparing which codes were reported in each of the sessions, patterns of attendance were established. Similar anonymously coded student data were collected from other units.

RESULTS
Over the four lecture sessions for which data were collected in 2011, only six codes were reported in every session, implying that perhaps only six students attended all four sessions. The overall pattern of attendance for the students enrolled in the unit (N=148) can be coarsely approximated by a binomial probability distribution, with the probability of attendance being ~35%. Data collected from several other sources validate this initial coarse approximation.
Analysis of student performance is reported elsewhere (Daniel, Mazzolini, Cadusch, & Edwards, 2012) but, unsurprisingly, students who attended all the instructional sessions showed higher learning gains, as determined by pre- and post-test scores, than students who hadn't attended any sessions.

CONCLUSIONS
Lecture attendance is surprisingly inconsistent. The approximate fit to a binomial distribution means it is almost as if each student flips a slightly weighted coin in deciding whether or not to attend each lecture. It is often assumed that if the number of students attending lectures is approximately constant, then roughly the same group of students are attending each lecture. This assumption about the same group of students attending successive lectures underpins the common practice of building on the understanding of previously presented material in each new lecture. This assumption, and the purpose and efficacy of the lecture mode more generally, have to be questioned.

KEYWORDS
Lectures, attendance, curriculum

Introduction

Learning in mathematics, engineering, and the physical sciences is tacitly assumed to be hierarchical in nature. Understanding of complex concepts is predicated on understanding the concepts that underpin them, and this is arguably more correct in these disciplines than it is in the humanities. This is reflected in the structure of our degree programs and the system of prerequisites, where there are strict rules about which units must be passed (and by implication understood) before enrolling in higher level units. The sequential nature of understanding is also reflected in the assumption that underpins the planning of lecture content for a specific topic, that most of the students in a particular lecture have attended the preceding lectures, and therefore have been exposed to the concepts that underpin the content being presented in the current lecture.

In a study into the effectiveness of Interactive Lecture Demonstrations (Sokoloff & Thornton, 2004) in building student understanding of resonance in an introductory electronics unit (Mazzolini, Daniel, & Edwards, 2012), the decision was taken to anonymously but uniquely track individual students' responses to the various activities. Rather than just pooling the responses of the students in each session, it was thought that this anonymous tracking would enable more detailed analysis of how different students responded to the activities and in particular to home in on the subset of students that attended all of the sessions. For these so-called Complete Responders, the effect of the education intervention should be most profound (Mazzolini & Cadusch, 2011).

The anonymous tracking of students offered an unintended proxy for tracking attendance. Unexpectedly, the particular students in attendance at each session varied markedly from lecture to lecture. This was surprising given that the lectures were *not* recorded *nor* made available online.

Some data from other units have been collected that corroborate these observations of substantial inconsistencies in lecture attendance. What do these inconsistencies mean? Certainly, the reasons for why students attend, or do not attend, lectures need detailed investigation.

Friedman, Rodriguez, and McComb (2001) surveyed more than 300 undergraduate students from a range of disciplines to try to understand the reasons why students do, or do not, attend classes. Friedman's group found that the only student characteristic that was correlated with attendance was grade point average, with higher performing students having fewer absences. They also found a number of unit characteristics that correlated with attendance. Surprisingly, the time of day the class was held was not among them. More important factors were:

- whether the unit was compulsory or an elective (elective classes had higher attendance),
- class size (bigger classes had worse attendance),
- whether or not attendance was checked (attendance not being checked was the strongest correlate with absences),
- content availability (if the unit content was available elsewhere (e.g. online) absences were higher),
- classroom practice (engaging participatory classes had higher attendance than classes described as 'boring'),
- category of unit content (i.e. social science, humanities, math & natural science, professional school, and laboratory courses). Friedman observed an interesting effect whereby when attendance was not checked, units in the natural sciences had the

worst attendance, whereas when attendance was checked, natural science subjects had the highest attendance.

The assumption that lecture content can be planned to build upon previously presented work is directly challenged, and more generally the function and utility of the traditional lecture mode must be questioned.

Method

As part of another research project involving Interactive Lecture Demonstrations (ILDs), each student was asked to supply a unique research code, that was subsequently also used for this current study. At the start of each activity session (several of which were associated with the ILD project), students were prompted to generate their own individual research code. These codes could be used to track individuals' responses across the different sessions whilst ensuring that the identity of the student was concealed, and that their responses would not be used to affect their assessment. Plain Language Statements (PLSs) explaining the project and the voluntary nature of participation were discussed at the start of the first session and a printed version of the PLS was distributed at each session.

In 2010, printed student worksheets were distributed for students to record their responses, which were then collected as students left the room at the end of the session. On the front page of each worksheet was a small box with a two-by-two grid, in which students were asked to enter the first two letters of their best friend's family name in the top row, and the last two digits of their phone number in the bottom row.

In 2011, audience responses devices (i.e. clickers), which were distributed at random to students, were used in conjunction with Turning Point™ software to collect student responses. The following prompts were used at the start of each session with the intention that every student would generate a unique but anonymous 5-digit numerical code:

1. The last digit of your mobile phone number
2. The last digit of your street number
3. The last digit of your birth month
4. The last digit of your postcode
5. Select your favourite colour [from one of ten different alternatives]

By comparing which codes were used in each session, individual students' responses could be tracked anonymously, and patterns of attendance could be deduced.

Data were also collected from two other sources, neither of which involved ILDs. The first two authors are also working on a different project to compare student feedback responses submitted by students completing an online survey, with feedback submitted by students in class on a particular day using clickers (Mazzolini, Daniel, & Mann, 2012). The number of students responding using clickers represented a snapshot of attendance for that day.

The third author used student-generated codes to match responses to pre- and post-tests in two life science units. Codes were generated using the first three digits of participants' fathers' birthdays, and the first three letters of participants' mothers' maiden names. Again, by comparing which codes were reported in the different tests, patterns of attendance were deduced.

Results

ILD attendance data

In the 2010 sequence of ILDs, students' research codes were collected in three separate sessions. The inferred attendance is shown in Table 1.

Table 1: Attendance over three ILD sessions in 2010

	All three sessions	2 out of 3 sessions	1 out of 3 sessions	No sessions†	TOTAL*
Students	23	26	69	40	158
Percentage	14.6	16.5	43.7	25.3	100

** The effective total number of students enrolled was taken as the number of students that sat the final examination at the end of semester.*

† The number of students not attending any sessions was inferred by subtracting the number that had attended one or more sessions from the effective total number of students enrolled.

In the 2011 sequence of ILDs, student codes were collected in four sessions using clickers. However, the number of unique codes collected over these four sessions exceeded the total number of students who sat the final exam. This anomaly probably can be explained as follows: some of the unique codes could be an artefact of where clicker responses were not recorded for one of the code prompts. For example, one of the five-digit codes submitted was **07464**. In another session, the code **0746-** was submitted, with the '-' meaning that a response wasn't registered for that last research code question. If in all such cases, we consider these as equivalent, that is we accept blank responses as wildcards, we get the attendance distribution given in Table 2. With this wildcard assumption, the total number of students attending classes correlates well with the number of students who sat the exam, and so in the following analysis we will interpret the data under this assumption.

Table 2: Attendance over four ILD sessions in 2011

	All four sessions	3 out of 4 sessions	2 out of 4 sessions	1 out of 4 sessions	No sessions†	TOTAL
Blanks as wildcards	6	13	41	86	2	**148**
Percentage (of 148)	4.1	8.8	27.7	58.1	1.3	**100**

† The number of students not attending any sessions was inferred by subtracting the number that had attended one or more session from the effective total number of students enrolled.

Normalised binomial probability distributions

If we assume that attendance is probabilistic, such that for any student there is a probability of attending any one lecture P_{attend} with

$$P_{attend} + \overline{P_{attend}} = 1,$$

then the attendance distribution over n lectures will correspond to the relevant terms in the following expansion:

$$N_{enrolled} * \left(P_{attend} + \overline{P_{attend}}\right)^n .$$

Or if we normalise by dividing by $N_{enrolled}$ the normalised distribution will simply be the binomial expansion

$$\left(P_{attend} + \overline{P_{attend}}\right)^n .$$

This expression is equivalent to the distribution of heads and tails we would expect from flipping a weighted coin *n* times.

ILD attendance analysis

In Figure 1 below, the measured normalised attendance distribution for the four ILD sessions held in 2011 has been plotted along with the least-squares fit of a binomial expansion with $P_{attend} = 0.351$.

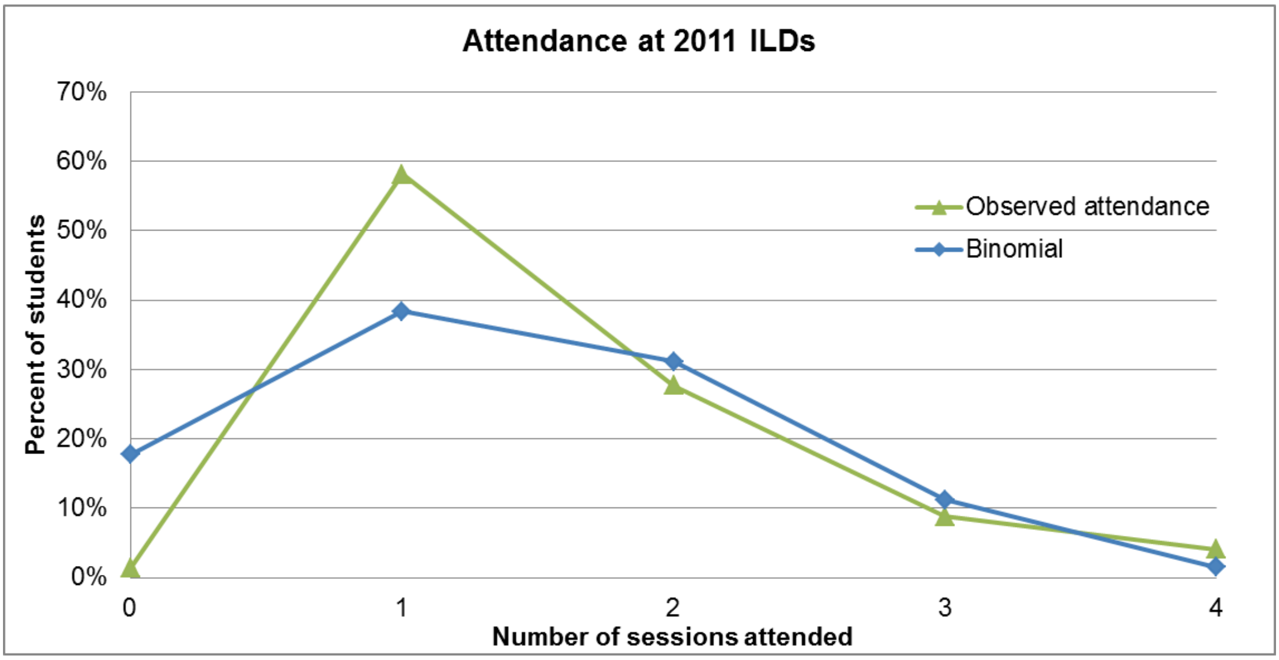

Figure 1: Attendance at 2011 ILDs

Decreasing participation rates

One confound with the attendance data from both the 2010 and 2011 studies was the decreasing participation rates throughout the studies. In the 2010 study, four different student worksheets were collected over three separate sessions, with decreasing numbers collected on each occasion (see Table 3). In fact, the drop-off in the number of worksheets collected was linearly correlated very strongly with the worksheet number ($r^2 = 0.96$). It should be noted that worksheet 1 (N=83) and worksheet 2 (N=67) were collected in the *same* lecture session, but a mass exodus halfway through the lecture was not observed. Clearly, some students simply did not submit their *ILD 1 Prediction* worksheets, even though they were in attendance. Therefore, if the same could be said for the *ILD 2 Prediction* and *Post-test* worksheets, our statistics will underestimate attendance.

In the 2011 ILD study, in which students participated by clicker responses rather than by submitting worksheets, a similar drop-off in participation was observed ($r^2 = 0.87$).

Table 3: Decreasing submission rates in the 2010 and 2011 ILD sessions

Activity	2010 ILDs		2011 ILDs	
	Content	Number collected	Content	Number collected
1	Pre-test*	86	Baseline test†	83
2	ILD 1 Prediction*	67	Pre-test & ILD 1	57
3	ILD 2 Prediction	61	ILD 2 Prediction	47
4	Post-test	38	Post-test	43

** The 2010 pre-test and ILD 1 Prediction were held in the same lecture session.† Note that the 2011 baseline test was given six weeks before the other three activities, prior to the traditional lectures on the topic, and the mid-term break.*

Although responses were counted in different ways (in 2010 by the number of students who handed in their encoded worksheets at the end of the session, and in 2011 by the number of students who used clickers to enter their codes at the start of the session), a similar drop-off in participation rate was observed in both years. In 2011, there was a long period between activities 1 and 2 (the baseline test and pre-test). Therefore perhaps it is appropriate to compare attendance patterns just across activities 2-4, held in consecutive lectures, with attendance at the 2010 ILDs, which were also held over three consecutive lectures.

In Figure 2, the attendance distribution for just the latter three consecutive lectures in 2011 has been plotted, along with the normalised attendance data from the three sessions in 2010. A least-squares binomial fit, with $P_{attend} = 0.334$, has also been plotted.

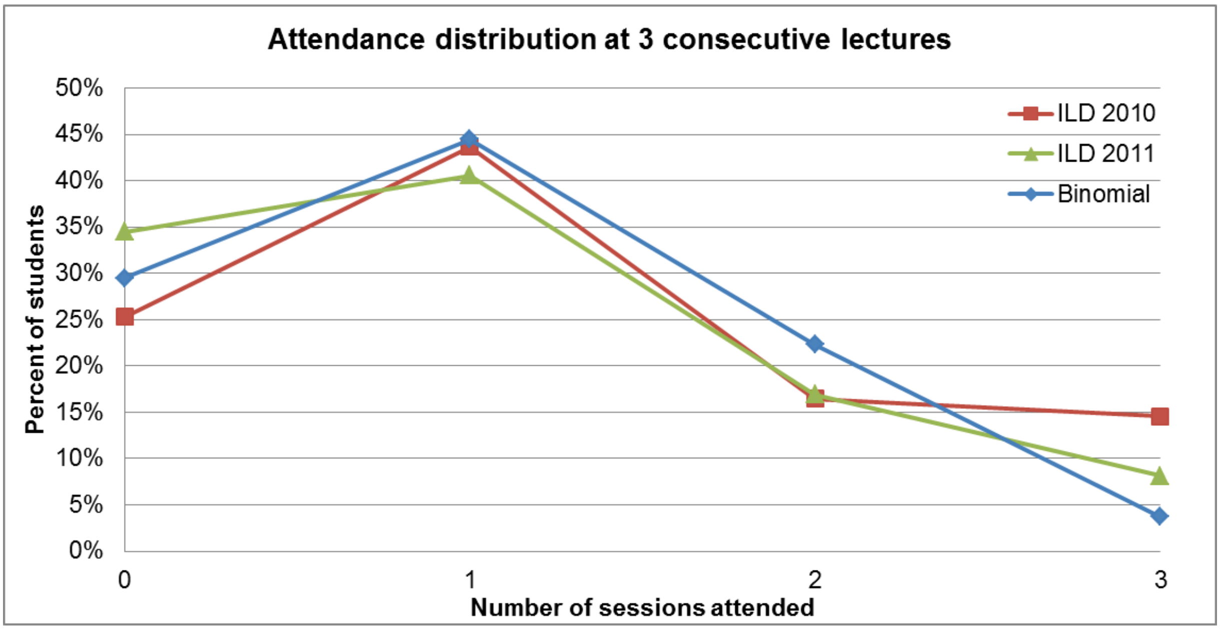

Figure 2. Attendance distribution at 3 consecutive electronics lectures

This plot is striking because it shows the patterns of attendance are almost identical to it being as if students merely flip a weighted coin in deciding whether to attend each lecture.

Perception of ILDs as interesting

One factor in attendance (Friedman et al., 2001) is students' perception of how engaging or boring a class is. In addition to explicitly designing the ILD sessions to be interactive, in the post-test session we also asked students if they agreed with the following statement: "I found the interactive lecture demonstrations (ILDs) on resonance more interesting than normal lectures." As can be seen from the distribution of responses shown below in Figure 3, the distribution is skewed towards the 'Agree' side: students found the ILDs *more interesting* than normal lectures, and therefore from Friedman's research would be more likely to attend.

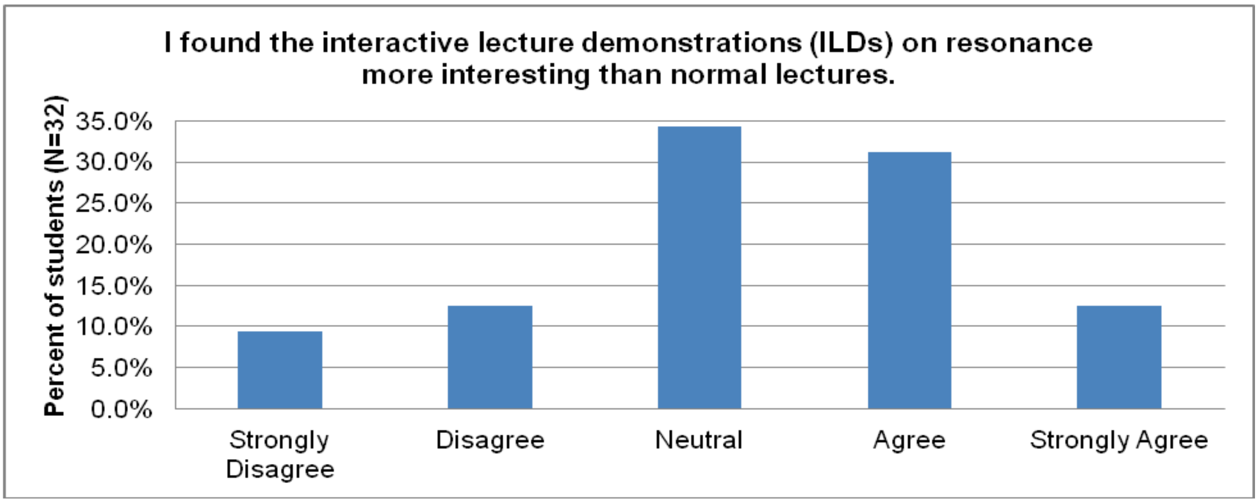

Figure 3. Reported opinions of students who attended at least one ILD session

Clicker-based student feedback surveys

Clickers were used to collect student feedback in six engineering units. These units did not use ILDs in any way, and so provide a valid point of comparison for lecture attendance. However, similar to the ILD study, participation was voluntary so these statistics provide a lower bound for attendance in each particular class. The measured attendance was 37 ±8 %.

Table 5: Attendance snapshots in six different engineering units using clickers

Unit	Responses	Enrolment	Percentage
A (intro)	68	163	41.7
B (intro)	56	178	31.5
C (intro)	67	149	45.0
D (intermed)	36	112	32.1
E (intermed)	66	225	29.3
F (final year)	38	89	42.7
		AVERAGE	37.1

Life Sciences classes

Student-generated codes were used to match pre- and post-test responses in two first-year life science units. These also did not involve ILDs.

Clearly, in the unit LIFE-1 students used different codes, as there were many more unique codes than enrolled students (see Table 7 below). If a student attended both sessions but used two different codes, these distinct codes would instead be interpreted as two students only attending one session each. Furthermore this would lead to the inferred number of non-attenders decreasing by one (as this student would have been counted twice as an attender).

In general, such inconsistent code use would lead to an over-reporting of attendance at only 1 session, and an under-reporting of attendance at 0 or 2 sessions. Conceding that this data is somewhat flawed, the least-squares binomial fit is shown below in Figure 4 (with the attendance at 'neither session' for LIFE-1 interpreted as zero), with $P_{attend} = 0.536$.

Table 7: Attendance patterns in two first-year life science units

		Both sessions	1 of the 2 sessions	Neither session	TOTAL
LIFE-1	Number	33	148	*?*†	138 (181)†
LIFE-2	Number	13	69	7	89

† The number of students who showed up for the final exam was 138, which is far less than the total number of unique codes (181). Clearly the prompts used with these two units to generate anonymous codes are insufficiently rigorous.

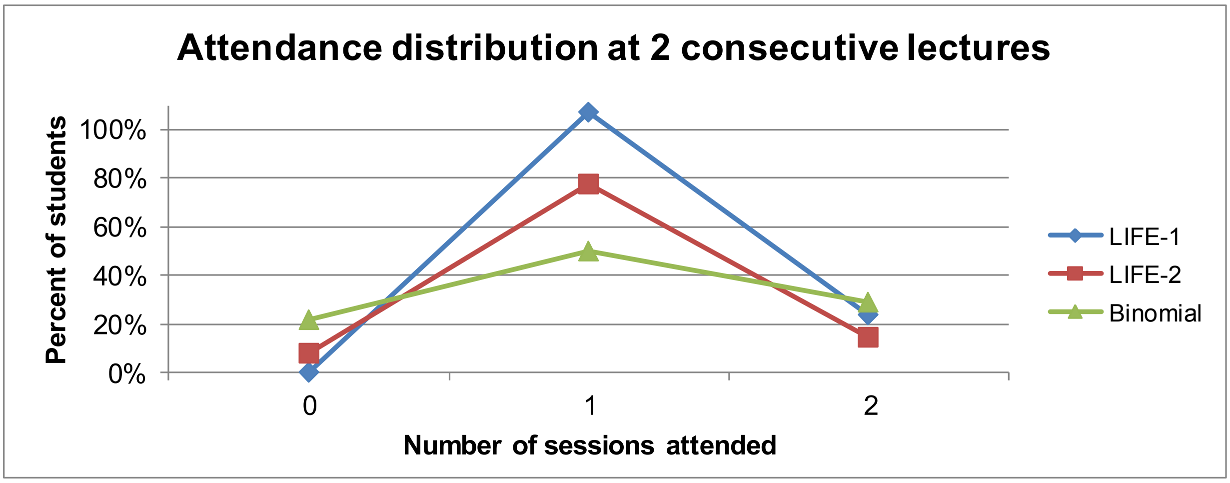

Figure 4. Attendance distribution at 2 consecutive life-science lectures

Results Summary

The above analysis is summarised in the following table.

Number of lectures	Data sets	Total number of students	P_{attend}
4	1	148	**0.351**
3	2	306	**0.334**
2	2	227	**0.536**
1	6	916	**0.371**

Table 8. Attendance analysis - summary

Discussion

The assumption that the probability of any one student attending a particular lecture is fixed for all students and constant throughout the semester is overly simplistic. The reality is that undoubtedly there are different subsets of the student cohort with varying probabilities of attendance, ranging from small subsets at the two extremes of almost none, or almost perfect, attendance, and the bulk of students in the middle. Nonetheless, the unsophisticated fit to a binomial distribution is disturbingly accurate for such a simple first approximation, and equally disturbing is the associated coin-flipping metaphor.

Several factors may have led to attendance being inaccurately reported. Students that were in attendance but did not submit worksheets or clicker responses would not have been counted, but this is unavoidable if ensuring informed consent. Also, students could have given different responses to the same code prompts in different sessions. This was certainly the case in LIFE-1. And for example, in the ILD2011 sessions, only the question about birth month would have an unchanging answer. In recognition of this, students were reminded at the start of each session that the purpose of the codes was to anonymously track responses and so were asked, if their details had changed, to respond as they had in previous sessions.

Friedman et al. (2001) identified a number of attendance ‘risk factors’ for units, and most of these were met by all the courses we studied. The attendance may be better in other units that do not share all these risk factors.

Risk factor	**Our units**
Compulsory unit	✓ All units were compulsory
Large class size	✓ Enrolment ranged from 89-225
Attendance isn’t checked	✓ No units checked attendance
Content available elsewhere	✓? Some units had lecture notes available online, but only in one case were recorded lectures available [Unit A]
Boring classroom	×? The 2011 ILD sessions were reported as interesting, the others weren’t investigated
Natural sciences (if attendance not checked)	✓ All units were in the sciences

Table 9. Attendance risk factors

Did the ILDs have an effect on attendance? This is difficult to discern. Few students reported them as less interesting than normal lectures, which as discussed earlier is a risk factor for low attendance. However, since students knew that the ILDs were designed to reiterate content that had already been covered in the preceding traditional lectures some students may have opted out of coming with the perception that attendance was superfluous. This may have contributed to the decreasing participation in successive sessions. However the binomial fit to the ILD attendance (P_{attend} = 33.4 %) was certainly comparable to the attendance measured through the clicker student feedback surveys (P_{attend} = 37 ± 8 %), which had nothing to do with ILDs.

Conclusion

Lecture attendance can be roughly approximated by a metaphor of students flipping a weighted coin in deciding whether to attend each lecture. This directly challenges the tacit assumption that the audience is largely unchanged from lecture to lecture, and that each successive lecture can be used a stepping stone in building student understanding.

How can we improve attendance? Friedman et al. (2001) identified several ‘risk factors’ for low attendance, which could be used as a basis to re-design units. One strategy would be to make attendance compulsory, or give some assessment weight to attendance.

But do we need to improve attendance? Friedman et al. (2001) argues that grades should reflect mastery of content and that “teachers should insist on attendance only when students’ presence is clearly essential for achieving their academic goals”. And if students are passing despite poor attendance, what’s the point of lectures?

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