Final Draft of chapter to appear in:
"Inclusion in Linguistics", Edited by Anne Charity Hudley, Christine Mallinson, and Mary Bucholtz, Oxford University Press

# Increasing Inclusion Through Structured Active Learning – A Case Study of Curriculum Changes in an Introduction to Formal Linguistics[1]

Florian Schwarz (he/him/his)

University of Pennsylvania

## Introduction

Various minority groups remain underrepresented in Linguistics. There are efforts to improve this situation to make the field more inclusive and diverse, as reflected in institutional commitments. The Linguistic Society of America's Committee on Ethnic Diversity in Linguistics was founded on the recognition that "some ethnic and racial minorities […] are significantly underrepresented in the linguistics workforce […], and that it is in the interest of the field of linguistics […] to be enriched by the participation of all its ethnic groups" (LSA, 1994). Similarly, many universities, such as my own, have explicit general commitments to inclusion: "[…] we must take responsibility for creating curricula and […] learning environments that are affirming and inclusive" (Penn Arts & Sciences, 2020).

Working towards greater inclusivity in introductory undergraduate teaching is one important piece of this endeavor. If the first encounter with the field fails to provide an inclusive environment, this inevitably undermines long term work towards diversity and inclusion. How can teaching become more inclusive? Research on Science, Technology, Engineering &

[1] Thanks are in order to a number of people. First and foremost, I could not have undertaken this project without Ryan Budnick, who was my Teaching Assistant for both the last pre-conversion class and the first class in the new format. He enthusiastically agreed to work together in the process, and went above and beyond in so many ways. Most importantly, he took on the huge task of taking the lead in creating the in-class problem sets, whose high quality is a key ingredient for the success of this teaching model. I also received invaluable support and guidance from Penn's Center for Teaching and Learning, and particularly benefited from input and advice from Bruce Lenthall, Emily Elliott, and Jamiella Brooks. The other graduate and undergraduate Teaching Assistants Alexandros Kalomoiros, Gwendolyn Hildebrand, Nikhil Lakhani, Michael Ehart, Stefan Pophristic, Tess Christensen, and Nikhil Avadhani have also contributed in many important ways to the success of the class over the different SAIL instances of the class.

Mathematics (STEM) teaching points to structured active learning pedagogy as an effective tool for increasing inclusion. This chapter describes the conversion of my Introduction to Formal Linguistics class, which covers concepts from discrete mathematics as tools for syntax and semantics, to what at Penn is called Structured Active In-Class Learning (SAIL). It reports data from three instances of the class post-conversion (from 2019-2021) with some comparison to pre-conversion instances in 2014, 2016, and 2018.

**Active Learning as a Tool for Inclusion**

The general approach of active learning pedagogy (sometimes also referred to as 'flipped' or 'inverted' classroom teaching) is to reduce class time spent on lecturing to allow more active engagement with materials during class. There also is an emphasis on engagement with materials before and after class, and a shift to more frequent, low-stakes assessments, with less emphasis on exams. A meta-analysis by Freeman et al. (2014) aggregates extensive evidence showing that active learning leads to performance improvements across all students in STEM classes. More recently, another meta-analysis by Theobald et al. (2020) on the impact of active learning on underrepresented minority and low-income students concludes that "Active learning benefits all students but offers disproportionate benefits for individuals from underrepresented groups. Widespread implementation of high-quality active learning can help reduce or eliminate achievement gaps in STEM courses and promote equity in higher education" (Theobald et al., 2020, p. 6476).[2] But the authors also recognize that structuring a class' curriculum along active learning principles alone "is not a silver bullet for mitigating achievement gaps" (p. 6479). They propose a 'heads-and-hearts hypothesis,' pairing active learning pedagogy with a culture of

[2] During current COVID-19 pandemic conditions, it's also highly relevant that active structured learning can be highly effective in online and hybrid teaching environments (Gavassa et al., 2019), which aligns with my experiences during the last two offerings of my course.

inclusion, which emphasizes "treating students with dignity and respect [(Estrada et al., 2018)] […] and demonstrating a genuine interest in students' intellectual and personal growth and success [(Fries-Britt et al., 2010, Salehi et al., 2019)." An analysis of underlying factors contributing to the enhanced benefits for some student populations by Eddy and Hogan (2014) finds that homework and the frequent opportunity to practice were especially valued by Black students. Furthermore, they report that in a traditionally taught version of the class, "[B]lack students were significantly less likely […] to speak up in class, but this disparity disappeared under moderate structure. We suspect that the increased sense of the classroom as a community may have contributed to this increased participation" (Eddy and Hogan 2014, p. 465). More generally, a decreased sense of belonging in students from underrepresented groups has been argued to affect decisions against majoring in STEM fields (Rainey et al. 2018). In sum, structured active learning together with an inclusive classroom culture provides a promising tool for more inclusive teaching.

## Active Learning Conversion of a Formal Linguistics Class

### *Background on Subject Matter, Audience & Place in the College Curriculum*

The formal linguistics class in question introduces tools from discrete mathematics and their use in linguistics. The emphasis is on general conceptual grounding and gaining facility with formalisms. The first module introduces set theory. The next module introduces formal language and automata theory, including regular and more complex languages. The third module explores context free grammars for modeling parts of English syntax. The final module introduces basic set-theoretic semantics, including basic statement logic. The overall goal is to introduce students to the use of formal tools in linguistic theory and to hone general analytical reasoning skills,

which are of use across the many disciplines and directions that the enrolled students from a diverse range of academic backgrounds wind up pursuing.

The course is introductory with no pre-requisites. It satisfies general education requirements in Formal Reasoning and Analysis and Natural Science Across Disciplines in Penn's College of Arts & Sciences. The class generally enrolls close to 50 students, including everyone from freshmen to seniors from various academic backgrounds, making for a diverse group in terms of familiarity with formalisms. Many humanities students see the class as a welcome alternative to the other course options for satisfying the College requirements, which most prominently include Calculus. But there also are students from computer science and engineering, who are curious how formalisms familiar to them are utilized in linguistics.

The nature of the materials, together with the diverse range of academic backgrounds of enrolled students, naturally lends itself to an active learning format. For most students, the formalisms covered in the class are entirely new, and mastering them requires a substantial leap from passively grasping the main gist of a given topic to actively being able to apply the relevant analytical tools in problem solving. This requires ample opportunity for practice with structured support along the way.

*Before Conversion: Traditional Class Structure*

The original class structure was traditional, with two 50-minute lectures per week and one additional meeting of two smaller recitation sections led by a graduate TA. Some of the elements of the course structure before conversion might already be considered moderately structured in the active learning literature: Nine homework assignments counted for 60% of the grade, and short daily quizzes after class for 10%. A midterm and final exam each counted another 15%.

A common complaint from students was lack of opportunity to practice skills before being evaluated for performance. While they appreciated the regular hands-on practice that came with homework assignments, the fact that this simultaneously was the first extensive opportunity for practicing skills but also counted towards 60% of the course grade made this less productive and more stressful than ideal for an initial phase of learning. Review and discussion in recitation sections also did not seem to offer enough active engagement with the materials, based on students reports. And while lectures frequently incorporated questions for the students, contributions mostly came from a small number of students with a strong formal background. This may have intimidated others, undermining their confidence in their own abilities. While I myself often stressed that the best way to learn was to use the formal tools on your own, there wasn't enough opportunity to do so.

*After Conversion: Active Learning Class Structure*

The new version of the class, with two extended 80-minute meetings per week to incorporate time previously used for recitation sessions, dedicates class-time almost exclusively to hands-on problem solving in small groups, paired with structured work before and after class. The previous lecture content was condensed into one to three short video lectures per class, lasting 15-25 minutes in total. Students were encouraged to also further engage with the lecture materials using the extensive written lecture notes, which were prepared by the instructor and formed the basis of the video lecture content. For each video, there was a short quiz due before class, and to be completed within a fairly limited amount of time (15-20 minutes). A total of 30 quizzes counted for 20% of the grade, with generous partial credit given for any answer attempts. The quiz questions drew on the previously used daily quizzes and basic-level questions from previous homework. Other previous homework questions focusing mostly on more complex

problems formed 10 assignments worth 30% of the grade. The midterm and final exams remained essentially unchanged (15% each).

The in-class group work formed the heart of the new class setup. Groups of 4-5 students worked at a table with ample access to whiteboard space (during online teaching, Zoom breakout rooms were used). I would start class with a brief review of core concepts, then groups turned to the day's problem sets. These generally began with basic applications of a given formalism (e.g., solving set theoretic equations), and then continue to more complex and open-ended problems (e.g., constructing an automaton that models a certain formal language). Problem sets were split into Basic Problems and Challenge Problems to provide enough stimulating materials for all students without expecting everyone to finish all problems. Each group member was assigned a rotating role, such as scribe, reporter (presenting group work to class), whiteboard person, or manager, as recommended by Johnson (2021, p. 210). Participation counted for 20% of the grade. Rather than evaluating based on amount of work completed or points for correct answers, full participation credit was given for 'making a good faith effort,' understood as everyone actively participating in groupwork, and the group as a whole working on the in-class problem sets throughout a given class. (Given high overall student commitment to in-class work, usually everyone present earns participation credits, with very few exceptions over the years.) Two undergraduate learning assistants were a key addition to the class to help support group work. Each of us would attend to 3 of 12 tables, rotating across class sessions. We answered specific questions or went over particular issues upon request, or casually dropped by and listened in to stimulate discussion as needed. Occasional breaks brought back the entire class to go over common issues or let groups report on their work.

In the first class, recommendations for group work highlighted the diverse academic backgrounds in the class, with varying degrees of ease with formalisms. The key guideline was to "help each other learn: If you already know materials well, use this as a challenge to think through teaching them to others. If all is new to you, don't be shy to ask questions" (Schwarz, 2021). In addition, students were asked to be kind and patient with each other, and encouraged to call on TAs for help. Finally, advice from prior students on how to do well was shared.

**Outcomes & Evaluation of New Class Format**

*Attendance*

One commonly voiced concern about providing virtually all course content outside of class time is whether students will bother to come to class at all. The participation component of the course grade, cumulatively worth 20%, aimed to counter this potential challenge. While no precise quantitative comparison is possible, due to lack of attendance data pre-conversion, attendance clearly was not an issue after the conversion, and most likely increased substantially compared to previous lecture attendance. Students very rarely missed class, not only because this was worth some points, but also because they experienced class time as extremely valuable learning time, as witnessed by the student feedback discussed below. Also worth noting, not only but especially in the context of the many challenges during the COVID 19 pandemic, is that the administration of in-class problem sets via Canvas (the Learning Management System used at Penn) made it easily possible for students with excused absences to complete these on their own, both to engage with the relevant materials and to earn participation points.

*Academic Outcomes*

Grade outcomes by class format for 286 students (140 in traditional format, 146 in SAIL) are summarized in Table 1.

| Format | Total | Exams | Homework | Quizzes |
|---|---|---|---|---|
| Trad | 87.3% | 87.3% | 88.8% | 78.5% |
| SAIL | 92.5% | 90.8% | 92.4% | 91.8% |

Table 1: Percentage of total points by grade category and class format.

Grades are higher in the active learning format. Mixed effect models with a random slope for Year were fit in R using the lme4-package to test for statistical significance of the differences, with p-values from the lmerTest package. STEM major was included as a second factor, in addition to class format. Total grades were higher in the SAIL versions ($\beta = .051$, SE=0.013, $p < .05$) and for STEM majors ($\beta = .037$, SE=0.009, $p < .001$). While there was no significant interaction ($p=.35$), the increase for SAIL was numerically greater for non-STEM majors: pairwise comparisons using the emmeans package find a significant increase of 6.0 percentage points (SE=0.016, $p<.05$) for these, vs. a marginally significant 4.3 point increase for STEM majors (SE=0.016, $p=.052$). A parallel pattern was found for exam grades, with a 3.3 point increase for SAIL and a 6.2 increase for STEM; again, the SAIL effect was driven by non-STEM students (non-STEM: $\beta = .046$, SE=0.015, $p < .05$; STEM: $\beta = .020$, SE=0.016, $p = .48$). For homework, the SAIL effect was marginally significant ($\beta = 0.37$, SE=0.015, $p = .064$), while the STEM major effect remained robust ($\beta = .032$, SE=0.009, $p < .001$). The SAIL effect was comparable numerically for both major groups. Quizzes saw the most dramatic increase in the SAIL format ($\beta = .13.3$, SE=0.020, $p < .01$), likely at least in part due to changes in questions; there also was a STEM effect ($\beta = .033$, SE=0.012, $p < .01$), and no clear difference in SAIL effect across major types.

In sum, grades improved throughout in the SAIL version, compared to the traditional format. STEM majors had higher grades than non-STEM majors both before and after, but at

least numerically, the gap between them shrank through more pronounced improvements for the latter group. (Note that statistically, this did not reach the level of a significant interaction.) This can be seen as a form of greater inclusion, making mathematical formalisms more uniformly accessible to different students. Unfortunately, it has not yet been possible to get access to demographic information on student backgrounds to assess grade outcomes more comprehensively with regards to potentially divergent outcomes for different student populations, but hopefully such analyses can be done in future work. Nonetheless, the present findings align with prior results showing that active learning improves overall student performance. This, along with findings from earlier work that students from underrepresented groups disproportionately benefit from this teaching format, provides some reasonable hope that the changes in pedagogical approach have real potential to increase inclusion in introductory linguistics teaching.

*Course Evaluations*

Penn's standard course evaluations allow for direct comparison of pre- and post-conversion instances. Mean ratings for relevant questions are summarized in Table 2.

| **Rating Prompt**<br>**(from 0 - Poor/Strongly Disagree to 4 -Excellent/Strongly agree** | **Trad.** | **SAIL** |
|---|---|---|
| Overall quality of the course. | 2.55 | **3.10*** |
| As a result of taking this course, I have a better understanding of factual knowledge, principles and/or theories in this area. | 3.34 | 3.47 |
| This course helped me to improve my ability to analyze, solve problems and/or think critically. | 3.05 | **3.32*** |
| This course helped me to understand how this field asks and answers questions. | 3.17 | 3.34 |
| This course challenged me to consider new ideas, concepts, or ways of thinking. | 3.08 | **3.40*** |
| As a result of taking this course, I am more excited by this field of study. | 2.63 | **2.98*** |
| Please rate the difficulty of the course. | 2.23 | 2.31 |
| Please rate the amount of work required for this course. | 2.12 | 2.40 |

Table 2: Means of responses to prompts on Penn's official course evaluations.

Student evaluations are higher for SAIL, and statistical significance was again assessed via mixed-effect models. The increase in overall course quality was significant ($\beta$= .55, SE=0.11, $p < .001$). Other individual questions with significant increases in ratings were 'ability to […] solve problems' ($\beta$= .27, SE=0.12, $p < .05$), 'challenged […] to consider new ideas' ($\beta$= .32, SE=0.11, $p < .01$), and being 'excited by this field' ($\beta$= .35, SE=0.15, $p < .05$). The small numeric increases in difficulty and amount of work required were not significant.

*Student Feedback*

In the SAIL version of the class, two feedback surveys were administered, in the middle of the semester and at the end. On a scale from 1 (strongly disagree) to 7 (strongly agree), students indicated that the in-class work prepared them well for homework assignments (6.14), and that feedback from the instructors/TAs in class helped their understanding (5.99). Similarly, they found working with their group helpful to increase understanding (5.73). This positive experience of the group-work arose in the context of groups working cooperatively and providing space for students to ask questions: the statement "I feel comfortable about telling the other members of my group when I don't understand something" was rated 5.91, and students also highly rated agreement with the statement that "The members of my group are all actively contributing to the in-class problem set work" (5.95).

The final survey included additional questions to assess effectiveness for learning of different course components. On a scale from 1 (not effective at all) to 5 (very effective), doing homework assignments (4.46) and in-class group work on problems (4.44) were rated to be most effective, followed by asking instructors/TAs questions during class (4.32) and doing the video quizzes (4.26). With regards to the in-class group work, working through the problems with

others was rated most effective (4.39). Explaining material to other students was almost as highly rated (4.36), followed by explanations from others (4.24). Overall, students rated the course structure as ‘well-suited for enhancing my learning experience‘ at 4.38.

Key ingredients to the successful use of group work for effective learning would seem to be a high level of comfort with asking questions, a commitment to helping others, as well as support from TAs. Additional individual practice outside of class in form of quizzes and homework was also seen as effective.

While these quantitative data present a compelling case for the success of the active learning conversion, personal experience and student comments provide an even richer picture. During group work, the classroom always was filled with an excited buzz of activity and high levels of energy. Students’ own words best convey their experience, e.g., on problem sets:

- “Doing it as a group made us focus more on having everyone understand the topics, and the fact that we were not graded […] also helped take a lot of the stressful aspects of problem sets away.”
- “ […] if they were graded based on answers, I would most likely would not have spoken up as much in my group in fear of offering a wrong answer that would affect my peers and my grade. I also would have been more focused on finishing […] rather than trying to understand the material.”

Other comments speaking to the effectiveness of the overall setup included:

- “The video lectures and subsequent in-class group work was an AMAZINGLY EFFECTIVE way of learning. As a hardcore humanities major, anything involving quantitative reasoning has always been a challenge for me but this class might be one of the best quantitative classes I’ve ever taken.”

- “I’ve never felt so consistently engaged and prepared in each class.”
- “I can't imagine just going off of in-class lectures and not having the in-class problem set time- it's so crucial to my learning.”

One of the most illuminating aspects of student feedback came from asking them “What advice do you have for future students who wish to do well in this course, both in general and with regards to the structure of the course?” In addition to a constant mantra of “watch the videos and come to class prepared, stay on top of your work”, a lot of the comments again speak to the importance of the in-class group work and contributing to making it productive and inclusive:

- “[…] the group work is crucial in making sure you understand the information adequately. Ask any and all questions you have!!”
- “Definitely reach out to your group mates when you have questions […] Group work helped reduce a lot of the stress and anxiety from thinking that everyone understands the topics (because most of the time everyone is also as confused as you are).”
- “Admit to your group when you don’t understand something! They will more than likely be more than happy explain, and hearing a concept explained by someone who just learned it themselves can be really helpful”
- “Befriend and work with your groupmates, they are your most valuable resource. Learn from them when they know more than you, and teach them if you know you’re right.”
- “Learn your group members’ strengths and work together as a team to solve the problems.”
- “Also, take the in-class problems seriously. It’s easy to get lazy and shift the burden of work to your group, but that won’t help you. You’ll just have to make up the efforts come homework or studying time.”

- “Watching the video lectures is so important! Don’t be the one person in your group who depends on the others to understand the material. Be sure to ask lots of questions when you don’t understand something.“
- “For a class heavy in formalisms like this one, having a little bit of fun with your group while you do the problems helps you to pick up the concepts”

As these comments vividly illustrate, the students are very much aware of what aspects of this class setup are most central to enhancing learning. In addition to the structured class components that help students stay on track throughout, it is the cooperative and inclusive spirit they see as entirely crucial for successful group work, much in line with Theobald et al.’s (2020) ‘heads-and-hearts’ hypothesis.

**Conclusion & Outlook**

The change to an active learning format for this class has led to higher student performance and is overall strongly welcomed by students based on their evaluations and feedback. While at present, a direct quantitative analysis of general issues of inclusion is not possible due to lack of access to demographic data, the overall positive outcomes together with the findings from the prior literature do point towards this teaching approach increasing inclusion. While there are many limitations, the hope is that this will provide inspiration for more active learning courses and investigation of their effects in linguistics. At Penn, the new class format has been welcomed as an addition to the department’s curriculum, and several other classes are now also using active learning strategies, including our Introduction to Sociolinguistics and a new introductory course on Data Science for Studying Language and the Mind.

In closing, I’d like to offer some reflections on various possible directions for extending the approach taken here. To anyone considering adapting their teaching in similar ways, but with

some hesitation on undertaking a major revamping of the relevant course, I'd note that it is perfectly possible to gradually incorporate active teaching elements over time. While the present course did undergo a focused overhaul, many of the changes had also been building up slowly over time, and then were fully integrated into the new format during the transition. Any structured activity that allows students to apply newly learned concepts in a supportive environment, and which fosters a collaborative learning experience where anyone might both get questions of their own clarified by others and do some explaining themselves, has the potential to contribute to a more inclusive class environment. Similarly, no undertaking of this sort is ever completely finished. For example, one promising direction is to combine the change in pedagogical methods with adjustments to the content and phenomena covered with an eye towards greater inclusivity, much in line with various other chapters in this volume.[3] While in the STEM context of prior research on active learning, this does not seem to have played much of a role, likely because of the (perceived) independence of the subject matter from issues of inclusion, this only seems natural as an extension of Theobald et al.'s (2020) heads and hearts hypothesis, especially in the linguistics context. First and foremost, this could start with revisiting the languages (and possibly dialects) that example data is drawn from. The empirical ground covered in my class is relatively narrow, due to its focus on formal tools. Apart from a few illustrative case studies from Luiseño and Warlpiri, as well as some exercises on formal properties of stress systems in non-Indo-European languages, the focus is mostly on Standard English. A systematic exploration of where there is room for a wider range of data from other languages or other dialects of English could further contribute to greater inclusion of students from different backgrounds.

[3] Thanks to Anne Charity Hudley and Hannah Gibson for related suggestions along these lines in the review process.

With regards to an extension to other classes in linguistics, there clearly is promise in utilizing similar approaches for the teaching of other subject matter, though it likely will require adjustments of various sorts. But as the field of linguistics is fundamentally concerned with analysis of one sort of another of different levels of linguistic structure – from minimal sound pairs to narrative structure - and the relation of linguistic form to its contexts of use, it seems highly suited for spending substantial parts of class time on students practicing whatever analytical skills are involved. Since much of linguistic data is, or can be made, easily accessible, our field indeed seems very well positioned to incorporate learning-by-doing into classroom activities. As a matter of both practical concern and availability of resources, it is worth noting that much of the effort in implementing curricular changes of this sort can be seen as an up-front investment with future pay-off. For example, by strategically using exercise implementations in learning management systems, which not only allow for automatic grading of practice exercises but also for extensive custom feedback displayed after work is submitted, the need for laborious manual checking of practice work can be avoided, while still providing extensive feedback for students to review. Taken together with the decreased need of teacher preparation for individual classes and lecturing, this leaves much more time and energy to work with students individually and in small groups in a more targeted manner, providing help and explanation where it is needed. In my experience, this is both seen as more effective by the students and in many ways more rewarding as an instructor.

One additional consideration if more classes in a given program shift in this direction is whether the novelty wears off for students, and whether their experiences of work-load and time management overall may affect the effectiveness of this type of approach.[4] Impressionistically,

[4] Thanks to Hannah Gibson for raising related issues.

student feedback overall suggests that many students genuinely see the format as providing a more successful learning experience, in a way that I would hope would remain stable even if taking multiple classes of this sort in parallel. But only time will tell – at least to the extent that this type of teaching format is more widely adapted. In any case, I'd submit that the overall evidence so far lends substantial promise to extending the relevant teaching strategies to other topics and contexts in linguistics. Hopefully, along with that, we can also gather more wide-ranging data to more comprehensively assess its success overall and its impact on increasing inclusion in linguistics in particular.

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