<u>Curriculum Design and Legitimate Peripheral Participation by Preservice Teachers</u>

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This paper centers on preservice science teachers and their participation in two curriculum design projects. We consider these projects as cases of legitimate peripheral participation. We believe that this form of situated learning describes these projects well and helps distinguish them from more conventional forms of teacher education. The work is real, and novice's design judgments are immediately tested in the complex world of professional practice. "Learning" by preservice participants is assessed not through individual papers or examinations, but through design critiques with their teams and through assessment of final coauthored curriculum materials and participants' own analyses of how well they worked in the classroom. In this paper, we present our theoretical perspective, and preliminary findings that we believe validate our theoretical and programmatic approach.

Theoretical Background

For both the design and analysis of our projects, we ground our work in recent research on social learning and science studies.

Situated Learning

Lave and Wenger (present a view of learning based on social rather than psychological dynamics. For them, knowledge and learning is about interaction with others in a particular context. They present learning as *legitimate peripheral participation*.

> It crucially involves *participation* as a way of learning—of both absorbing and being absorbed in—the "culture of practice." An extended period of legitimate peripherality provides learners with opportunities to make the culture of practice theirs (Lave and Wenger, 1992, p. 95).

Newcomers engage in real – i.e. legitimate – work that is connected to the work of *old timers*. In doing so, the newcomers become socialized into the field as their participation becomes more central.

Wenger (1998) extends this view of learning as a social process in his conception of a *community of practice*. Such a community includes a *shared repertoire*, a *joint enterprise,* and *mutual engagement*. A repertoire refers to the tools, actions, concepts, language, etc. of the community. A shared enterprise is a common goal or set of goals pursued by the community. Mutual engagement refers to the interdependence within the community.

Science & Technology Studies

We also draw on work in Science & Technology Studies (S&TS) - particularly the sub-field of the Social Construction of Technology (SCOT), both for theoretical and methodological perspectives. Researchers in S&TS start from a position that empirical evidence itself is insufficient to determine scientific fact. They focus on exploring the social interaction that must therefore occur to change observations into facts. Latour and Woolgar (1986) describe this as an agonistic process, whereby scientists employ allies and artifacts in order to construct a certain reality.

Collins and colleagues have formalized the study of this process in the Empirical Programme of Relativism (EPOR) (cf. Collins, 1981a; Collins, 1981b; Pinch, 1981). They set out two critical stages to illustrate in investigating science. In the first stage, scientific observations are shown to have *interpretive flexibility*, that is, a variety of possible explanations. The second stage is to show the mechanisms by which that initial interpretive flexibility diminishes, and the scientific community reaches *closure*. Work on which closure - i.e. agreement - is reached become critical tools in the agonistic process over future issues. Latour (1987) gives the example of the structure of DNA, for which there is a high degree of interpretive flexibility in 1951, but is a taken for granted conception usable for future research in 1985. This is a case of a black box – a conception, routine, explanation, etc. that has been well established, and thus is used without examination of the interior structure.

Pinch and Bijker (1987) extend the approach of EPOR to the development of technology. SCOT's stages parallel EPOR's: initial interpretive flexibility will be reduced through social interaction until a technological artifact is stabilized through closure mechanisms. It is important to note that variation in interpretation is manifested not only in the results of a technological design, but in the goals of a technological design itself. In their case study of the development of the bicycle, Pinch and Bijker illustrate how different social groups (e.g., society women as opposed to young men) had different priorities and therefore different conceptions of what a bicycle was (a convenient means of transportation versus a piece of sport equipment).

Bijker (1987) further extends the importance of different perspective amongst groups through the concept of a <u>technological frame</u>. This is intended to be a broad concept, including the concepts and techniques used by a social group in solving a problem - recognizing that problem solving includes recognition of what the problem is – and is somewhat analogous to Kuhn’s (1970) paradigm (Bijker, 1987). The technological frame plays a crucial role in determining a social group’s perspective on technology formation:

> [T]he meanings attributed to an artifact by members of a social group play a crucial role in my description of technological development. The technological frame of that social group structures this attribution of meaning by providing, as it were, a grammar for it. This grammar is used in the interactions of members of that social group, thus resulting in a *shared* meaning attribution … The interactional nature of this concept is needed to account for the emergence and disappearance of technological frames. (Bijker, 1987, p. 172)

Bijker thus intends for the technological frame to be not a characteristic of individuals, but a mediation for the interaction between actors. He also points out that it is involved in how social conditions shape technological solutions and how technical solutions shape social conditions.

Themes and Goals

Three themes from our theoretical perspectives deserve emphasis when considering the goals and design of our program. First, knowledge, including the development of expertise and technology, is considered the product of social collaboration and interaction. This is not limited to pure content. Pedagogical strategies are established by the support of relevant actors. Second, knowledge is contextual. Routines, conceptions, artifacts, etc. have particular meaning in different locations, for different people. Coverage of a particular subject in one type of class is different than in another. Lastly, actors and artifacts exists in a network of interdependence. The teaching in a particular classroom is not and should not be an isolated event.

These conceptions of the production of knowledge, expertise, and technology contrast with traditional efforts in curriculum development, both in general and in the context of preparing new teachers. Significant efforts are often made to make such work linear, the content is considered predetermined and unproblematic, and novice curriculum developers have little interaction with experienced developers or each other.

Consideration of our theoretical perspective and the usual experience of preservice teachers leads us to two general goals for our curriculum development project. The first is to give the students an authentic experience of collaborative curriculum making – to involve them in legitimate participation. This means providing the opportunity for students to make critical decisions about content and creating an environment where students are sensitive to a variety of interacting factors. It also means having the occasion to work with non-peers and the products of previous work.

The second goal is to provide the opportunity for students to re-open closed black boxes. Consideration of various conceptions of teaching and teacher knowledge (cf. Shulman, 1987; Shulman, 1986; Posner, 1982) lead us to the view that teachers should have a meta-level understanding of the content they teach. Such an understanding depends on not taking for granted conceptions of content and pedagogy. We hope that working in collaboration will provide a greater opportunity for students to re-examine taken for granted conceptions, compared to working individually.

Curriculum Development Projects

The first project is a semester-long curriculum design course. It is one of two choices that preservice science teachers at Cornell have to complete a program curriculum requirement.[2] However, students are free to take the course at different stages of their program and the course is open to students not enrolled in teacher education. The semester we report on in this paper enrolled teacher education students at various stages (those with little or no education coursework, those with some coursework but no student teaching, those with student teaching in the last semester of the program), several psychology students, an elementary education student, an English major and a microbiology doctoral student.[3] The course is designed to provide increasing participation by students in curriculum design. The students' first interaction with schools involved observations and interviews with students, teachers, and administrators, but no teaching. Their second interaction involved teaching a unit designed by the course instructors (the authors of this paper). For the third experience, students worked in groups of 4-6 to design a single lesson within a 3-4 four lesson unit. The topic of the unit and its rough segmentation into lessons was determined jointly by the students and instructors, and was attentive to local environmental issues in cooperating schools. Finally, the fourth experience involved groups of 4-6 designing a full multi-lesson unit. The course has run for several years, each time with some variation in content focus. This paper primarily focuses on one group, referred to as Group 2, within the third experience.

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[2] The other option is a graduate course in curriculum theory and analysis.

[3] Cornell's teacher education program certifies teachers in science, mathematics and agriculture. The teacher education students in the course were in these subjects. The elementary education student is in a separate program.

The course also benefits from being part of a wider curriculum and professional development project called Environmental Inquiry (EI). This project provides previous designed material, experienced staff, and secondary school partners.[4] It was a desire to bring the advantages of this association to the student teaching experience that spawned the second project, an experimentation with the usual student teaching program. It involved student teachers during a two week intensive workshop immediately prior to their student teaching practicum. The project, dubbed the "Inquiry Project," sought to have students work in collaboration to create a community of practice for their student teaching experience. Students were divided into three groups of 5-6 students, each with a role in supporting a unit using bioassays and peer review to study toxicology. Some materials for such a unit had already been developed as part of the EI project. This paper primarily focuses on the Student Team. (There was also a Teacher Support Team and a Nature of Science Team. Appendix A includes the assignments given to each group.)

History

To orient our discussion, we give a brief history of the work of two curriculum development groups: the Student Team working on the Inquiry Project, and Group 2 working during the Curriculum Design Course. We present them in the chronological order in which these specific groups worked: first the Inquiry Project, and then the Curriculum Design Course. The participants in each project group are listed in Appendix B. (Note that Darrin is a member of both groups. Two other teacher education students participated in both projects, but were not in the focus groups of this paper.)

<u>Inquiry Project</u> – The charge to the Student Team is shown in Appendix A. The group began with some uncertainty about how to proceed. They quickly agreed that the bioassay materials

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[4] One particular association that should be specifically noted was a secondary teacher with a long history of involvement in the project who was on campus for a sabbatic.

they had been asked to review were, as Darrin often put it, “too much.” They were concerned that the project would overwhelm students. They considered creating their own, smaller packet, or using only some of the material. Ian was an early opponent of rewriting.

Their concern over the amount of material and what to do with it also interacted with early efforts to construct a pretest/posttest. They were concerned with how the test would match with provided instructional materials or whatever substitute they constructed. However, this led to a realization that the pretest/posttest was not supposed to be a test of coverage, but of students’ conceptions. This allowed the group to disentangle the problem of what content the material (or a successor) would cover from the problem of what content would be relevant on the test. Nevertheless, the content of the test itself remained problematic. Of particular concern was how to test for certain understandings without depending on other knowledge, particularly of technical terms.

Their work with the bioassay materials meanwhile became more intertwined with other tasks. While various degrees of reworking were proposed, the preservice teachers’ general concern was for making something more palatable for students. Nate made a connection between this general concern, and another assigned task of adapting material for a special needs group. He proposed, and the group agreed, to create a 4-5 page version aimed at weak readers, but usable by all students.

Work on the test continued with concern over using terms (e.g., “toxicity”) with which students might have a variety of conceptions. Discussion on test items involved fluctuation between various proposals by group members until a question was formed that focused on the target conception. Thus, for example, they formed as their first question simply, “How do you know if something is toxic?” During a discussion with all three groups, one of the course instructors pointed out that in everyday life, knowledge of toxicity often depends on trust in others. This led to an alteration of that question into asking students how they would explain the word "toxicity" on a warning label directed to a younger sibling. The instructor also suggested use of a scenario to test students about bioassays. The group used this suggestion to form the remainder of their test.

Finally, the adaptation of the bioassay materials made one final shift. The group decided, rather than making 4-5 pages of written text, to make a series of handouts/overheads that would guide class discussion. This was influenced by a desire to provide tools for teachers' lectures, a concern for weak readers, a perception that this was an easier way to reach consensus on what to include, and, perhaps most of all, a concern that the group was running out of time. The Student Team's final product consisted of a pretest/posttest on student conceptions of toxicity and bioassays, and a series of handouts/overheads covering the main points of conducting a bioassay experiment.

<u>Curriculum Development Course</u> – For the year reported here, the Curriculum Design Course focused on urban water issues, in part due to the location of the cooperating school. The class as a whole decided to design a unit focusing on pollution in a river in the city where that year's cooperating school is located. This decision was motivated primarily by the school's students citing river pollution--especially leakage from a particular company's chemical storage tanks--as a local environmental problem. After brainstorming possible activities, the course instructor (the first author) proposed the following three lessons: 1) an informational overview providing a history of the problems; 2) a lesson teaching concepts of concentration, possibly including a physical manipulative; 3) a lesson involving physical modeling of the storage tank leakage. The

deliberative process undertaken by the curriculum design students is exemplified in their planning for the second lesson.

Group 2 began with a focus on "parts per million," and established that understanding as a conceptual goal. This led to a consideration of various materials that could be used as examples, including money, Kool-Aid, and sprinkles on brownies. The students also considered whether and how they could demonstrate bioaccumulation and chronic versus acute doses, and whether to talk about specific, real toxins. The "ppm" notation remained an assumed central component of the content.

At this point, two members of the group, Merideth and Lou, had an opportunity to meet with an emeritus professor in the Department of Education who has significant expertise in teaching difficult scientific concepts through everyday, hands-on experiences. They described their idea of modeling concentration using number of sprinkles per brownie and Kool-Aid. The professor pointed out that neither of those substances is really toxic to students. He suggested showing battery acid being diluted with water, and asked students when they would be willing to drink it. He also suggesting a discussion of where a glass of water came from. However, the two students related none of these ideas into the general discussion when the group next met. Meanwhile, Group 3 made a change from modeling the cause of river pollution to modeling methods of cleaning up a polluted river. This change had little effect on Group 2, but a later shift by Group 3 would be more significant.

Group 2 continued trying to develop an activity demonstrating parts per million. They struggled with how to connect the logistics of preparing solutions (scoops of Koolaid per gallon of water, mg per liter) and the ppm notation. For the Koolaid, they were envisioning having students prepare their own preferred concentration, and create dilutions from there. They were also concerned with matching up their lesson with the preceding and following lesson. It also occurred to the group to consider what would and would not be necessary given the previous understanding of the students. This led first to expanding the focus to toxicity rather than just concentration, and in turn, to considering including a daphnia bioassay. Bioassays had been previously mentioned by Darrin, recounting his experiences with students' conceptions of concentration during the Inquiry Project.

At this point, the group grew concerned with the time necessary to include a physical manipulative demonstration, a dilution activity, and a bioassay, and started to consider logistical ways of accelerating the activities. The connection with toxicity and the real world continued to be a concern. They struggled with the issue that a preferable mix of Koolaid is safe for humans but toxic to daphnia.

Meanwhile Group 3, having struggled with how to model river cleanup, independently came up with redesign for the three lesson sequence that involved starting a bioassay on the second day. This stabilized both the preparation of a standard dilution and the testing of the dilution on daphnia. Finally, the group settled using a mixture of black beans and white beans (different numbers of black beans in a Ziploc bag full of white beans) for a visual illustration of concentration.

Discussion

For the remainder of the paper, we discuss illustrations of our theoretical framework manifesting in the two projects. We present six general themes.

<u>Cases of Legitimate Peripheral Participation</u> – Each project was a successful case of Lave and Wenger's notion of legitimate peripheral participation. The work was real – in both cases they were preparing curriculum for actual students. This legitimateness included the problematic

elements of the field. Participants struggled with factors such as time, variation in students previous experiences, and linkages to other parts of the curriculum.

Each project also included varying degrees of centrality in their participation. No groups started from scratch. The Inquiry Project explicitly asked participants to work from the products of previous endeavors by more experienced teachers and university faculty. During the Curriculum Design Course, participants go through a sequence of experiences of increasing involvement: they start with a guided needs assessment visit to the cooperating school; conduct a lesson designed by the instructors; design a lesson within a framework guided by the instructors; and finally, design an entire unit.

Both groups also had access to a variety of expert individuals. The instructors played a more formal role of old-timer, but other people – education faculty, secondary school teachers, science researchers – provided critical connections. It is also significant to point out the varying degrees of expertise amongst the students themselves, particularly within the Curriculum Design Course. By not requiring students to take it at a certain point in their program, and by being open to others, the participants themselves represent a range of comparative newcomers and old-timers in a variety of fields.

Interpretive Flexibility and Closure – The groups' curriculum development work exhibited cycles of variety and stabilization, as described by SCOT. Participants would exhibit interpretive flexibility with regard to solutions to their present problem, engage in social negotiation, and eventually reach closure on a particular conception. For example, the Student Team was initially uncertain what their charge of "Reviewing materials for student use" would entail. This quickly stabilized on some form of simplifying the present materials. How to do so became the new problem for which there was initial interpretive flexibility. A 4-5 page version and then a series of handouts/overheads were two subsequent points of stabilization.

In their negotiation, participants used allies and artifacts to support their particular position. In presenting an explanation of ppm, Ellen made reference to “my PI[5].” During his work in the Curriculum Design Course, Darrin, the student who had done bioassay experiments in his student teaching made several references to that experience, particularly with regard to student understanding. There were also instances of failures in social negotiation. The two students who met with the emeritus professor were the weakest students in Group 2. Thus they were unable to introduce any of those ideas.

Opening Black Boxes – The social work provided significant opportunities for opening black boxed conceptions – those conceptions who’s internal structure is well established and otherwise left unexamined. Appendix C shows a portion of the Student Team’s discussion about the term “toxic” that occurred during their efforts to construct the pretest/posttest. In having the discussion, the students directly address a typically taken for granted notion.

Several additional points, however, need to be made with regard to this process. First, it is unclear if students have the necessary tools to effectively reach closure once such black boxes are opened. For example, in considering a special needs group, the Student Team had a similar concern with the meanings of the terms “ADD” (Attention Deficit Disorder) and “ADHD” (Attention Deficit Hyperactive Disorder). While the students arguably have fair amount of expertise to address the toxic issue (and eventually consulted a dictionary), they had little expertise to address this issue. However, their means of closure, namely one or several students presenting a plausible sounding explanation, was used in both cases. Time, or lack thereof, was also often a significant means of closure.

Second, not all black boxes get open. Of course, it should be pointed out that doing so would be counter productive, and likely impossible. However, there were instances where, despite the use of significant black boxed concepts in social collaboration, the inner structure of those concepts was left un-addressed. For example, while the ppm notation eventually fell out of the design of the Group 2 lesson, the participants never discussed why that notation and concept is used in science.

Third, stabilization is not deterministic. The participants are not simply rediscovering old ideas. For example, by chance, both groups (the Student Team and Group 2) opened up the black box of the daphnia bioassay. Both groups addressed the questions why are daphnia used, and what is the connection between toxicity for daphnia and toxicity for humans. However, each groups reached closure on a different concept. The Student Team concluded that daphnia have logistical advantages (short lifespan, cheap, observable physiology). The Curriculum Develop Course participants as a whole settled on the explanation that daphnia are part of the base of the food chain, and therefore tests of daphnia are in part, tests of the ecosystem as a whole. A significant factor in this form of closure was a student (not in Group 2) whose technological frame included a concern for installing ethical considerations into scientific work. For her, using daphnia as an indicator species was a more viable point of closure than as a convenient experimental organism.

Technological Frames – As illustrated by the previous example, students exhibited different and significant technological frames – that is, characteristics of a participant's orientation towards the design process. Such frames do not have to be in conflict in order to be different. In Group 2, several students included in their frame a view by which their charge of designing a lesson on concentration meant teaching ppm. However, this stemmed from different sources.

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[5] This is presumably a reference to the Primary Investigator on the research project Ellen was involved.

Ellen, the microbiology doctoral student, for example, felt that ppm is the essence of concentration. For her, the two were inseparable, exclaiming at one point, "but that [ppm] *is* concentration." For Meredith, however, her concern was students' scientific literacy. She felt students should know what ppm meant for when they see it in the media.

Unfamiliarity with Legitimate Practice – Students occasionally exhibited an awkwardness or uneasiness with the ambiguous or open nature of their work. Most groups started out questioning what their task was. This was not simply an unawareness of the task itself, but an unawareness of the role they play in determining the task. On the other hand, there were clear instances where participants realized their control of their work.

Groups occasionally found difficulty in moving from a point of closure to the next stage of their work. Essentially, while they had reached closure, they were unaware or lacked the confidence that they had. For example, Group 3, when focusing on cleaning up river pollution, realized that not knowing what were some of the real pollutants was inhibiting their attempts to come up with modeling strategies. However, they continued to deliberate over possible strategies rather than research the river pollution..

This does not mean that groups remained aimless. However, when there was such a transition, it was often aided by a meta level action. For example, Nate would often make a summary statement. This was also a significant role for the instructor during the Curriculum Design Course. Such roles were examples of newcomers' work being aided by old-timers.

Interdependence – There were instances of interdependence, both between groups and between tasks within a group. Significantly, students were aware and concerned with addressing such interdependence, particularly with the Curriculum Design Course, where the different group projects where intended as a unified unit.

This interdependence had a significant effect on the stabilization of group work. For example, while Group 2 independently considered incorporating a bioassay, the proposal by Group 3 did much to stabilize their decision and the particular design of their lesson. For the Student Team, their linkage of the special needs task with the material review task also was a stabilizing factor for their work.

Conclusion

In general, we found these projects to be a productive application of our theoretical perspective for both programmatic and research interests. When student engage in legitimate curriculum design, significant social learning takes place. Students moved from being non-professionals to newcomers in the field of curriculum design. The SCOT model of alternating variety and stability provided a enlightening framework for investigating participants' work.

Appendix A - Inquiry Project Team Charges

Student Team – Responsible for resources related to student understanding. This includes (a) Reviewing materials for student use; (b) Developing a web-based pretest/posttest to gauge students' understandings of toxicology and bioassays; (c) Identify one or two special needs student populations (e.g. one language minority group and one specific learning disability), and (d) Adapting selected instructional materials for use by those special needs populations.

Teacher Support Team – Responsible for resources for teachers. This includes (a) Developing, publishing, and maintaining a recommended timetable for carrying out the bioassay protocol and/or exploration, (b) Constructing and/or modifying an inquiry-oriented lesson observation instrument (for use by student teachers and other teachers), (c) Determining needed supplies and assembling bioassay kits for all participating teachers (e.g., seeds, filter paper, deicers, instructions), and (d) Creating a frameowkr for teacher pairing that assigns each student teacher a cohort partner, and guides their work in visiting each others' classrooms and evaluating their Inquiry Project implementations.

Nature of Science Team – Responsible for resources related to teaching and learning about the nature of science. This group will (a) Develop a web0based tutorial on peer review (we will give you a draft tutorial to work from), (b) Write and evaluate pretest/posttest items to gauge students' understanding about the nature of science, especially the role of peer review (these items will be incorporated into the instrument developed by the Student Team), (c) Prepare a paper instrument for student teachers that documents the implementation of the Inquiry Project in their classroom.

Appendix B – Project Participants

Inquiry Project	
Nate	Biology
Nancy	Agriculture
Emily	Earth Science
Darrin	Biology
Ian	Environmental Science
Sarah	Biology
Curriculum Development Course	
Meredith	Cognitive Psychology Senior
Lou	Agriculture Pre Student Teaching Teacher Education Student
Darrin	Biology Post Student Teaching Teacher Education Student
Sean	Biology Pre Student Teaching Teacher Education Student
Ruth	Agriculture Pre Student Teaching Teacher Education Student
Ellen	Microbiology Doctoral Student, Education Minor

Appendix C – Toxic Discussion

Nate	**Nancy**	**Emily**	**Darrin**	**Ian**	**Sarah**	**Multiple/Unknown**
Okay, Um.						
One question I'd like to ask before we get started, is whether, we want to use,						
Well, it has to do with the wording.						
Like, toxic						
One pitfall we might have, is if we start asking, if we ask a question about toxic, or something about toxic, and the person doesn't know what toxic means, then, we get, nothing more than they don't know						
So, should we			Poison?			
use, say toxic, and, or poisonous, or should we, like						
Should we use both words, should we just use poison?						
	Should we say toxic ????					
				Poison and toxic, are, there's also a distinction, so we might also be creating a misconception, there, by associating them		

Or we could ask one question, what's the difference between being toxic and poisonous?		Toxic is supposed to be like it can kill you. Right?			
			What's the distinction between toxic?		
			I don't think I understand.		
I don't know ??					???
		I think toxic means its deadly, and poisonous doesn't.			
			No.		
I think toxic is scientifically defined					???
	Yeah		Yeah		
and poison is kinda, like a	and I think poisonous is very general				
literary term.	When I hear poison, I hear don't eat it				
	when I hear toxic, like, ?? large quatities.				
		Well I think toxic's worse		There's lots of toxins, I mean	
				There's toxic things, in, your carrots, if you, ??, if you, you have carrots	
				there's toxic in carrots, there's toxic in potatos	
				There natural toxins.	
	Cyanide in apple seeds				
I think scientists probably use the word toxic because its better defined and its not as much in natural speech, everyday speech, so					

	Do we have a dictionary?		
People say, something's poisonous, they can	???		
like, poison's a very used word		?? Probably ??? middle school kids.	
Um, and, like, its got lots of baggage			
Wereas, like you can say something, were, its got toxicity, but its very low, or something like that.			
But you cannot say, its, its poisonous, but very low!			??
[laugh]	It's not very poisonous!		
It's not, too too poisonous.			
It's under the government acceptability for poisonous.			
[laugh]	[laugh]		
			Okay.
But I think that, we should			
	Yeah		Poison might also be more, in reference to, consumable supstances, as opposed to toxicity being, you know, UV, or, rad, other kinds of radiation
Right, you wouldn't say UV was a poison.			
			Right
	??		
I think it's more of a literary, like, I mean, poisonous is more of that kind of			
Used in			

Okay.

So what do you want to do with that, though?

Uh, ??

Do we define toxic, as the, as the

I think

I think we should define toxic, because, what, I mean, if they don't know what the word toxic means, using poison isn't really a good substitute

We just established that its not a great substitute

Because we have problems with it, let alone them.

Yeah

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