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ABSTRACT

Science, Technology, and Society (STS) orientations can serve to integrate educational change as identified by the National Science Education Standards and Project 2061. Students learn through discovery with the help of STS and make connections within the real world. The implementation of STS orientations into the science curriculum requires teachers and students to take more responsibility; however, the benefits of STS are in line with education reforms. This paper provides an overview of discussions on STS orientations into the curriculum and develops a shared philosophical practice about them within the curriculum in order to bring different communities together in research, practice, and theory. (Contains 38 references.) (Author/YDS)

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THE PHILOSOPHY, THEORY AND PRACTICE OF SCIENCE-TECHNOLOGY-SOCIETY ORIENTATIONS

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Philosophy and Praxis

If Science, Technology, Society (STS) orientations are fully understood and implemented they can serve to integrate the many facets of science education reform such as those proposed by the National Science Education Standards and Project 2061. While other orientations could also facilitate this integration, STS orientations have historically characterized student development on a more holistic and philosophical level than other current perspectives and take into account the broader concerns of the science curriculum, student development, and teacher development. However, it seems that guiding frameworks have not been as fully developed that can serve as a strong basis for these approaches, especially in advancing further research and practice. Or the problem may be in getting the theoretical frames and practice together as praxis, "that ideal dialectical interplay between theory and practice, which is the basis for critical, reflective action, [which] can arise neither in the classroom nor in the exigencies of direct practice, but only in the relation between them (Lemke, 1994, p. 4)." We might add philosophical to Lemke's definition as the broader factor that helps bind together and interpret the three (Figure 1).

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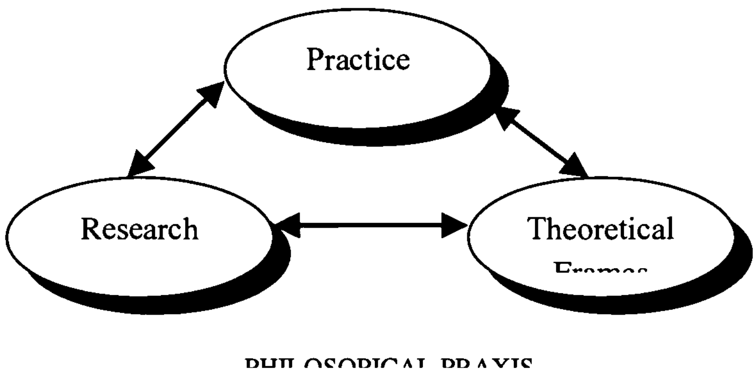

Figure 1: Philosophical Praxis as the Interplay of Research, Practice, and Theoretical Frames

This praxis is meant to include university level science educators, teachers in K-12 classrooms, preservice teachers, and graduate students in science education. A focus of this paper is in developing shared philosophical practice that brings different communities together as a starting point in researching, practicing, and theorizing about STS orientations to the curriculum. So many have contributed to the discussions and writing that we find it hard to adequately give them credit. This paper describes the evolving discussions and key considerations in understanding and promoting STS orientations through these communities.

Evolving Praxis: Graduate Level Coursework in STS

Last fall in our graduate student seminar, we focused on STS orientations to the curriculum. We started by reading the literature on situated learning, worldviews, and different subcultures students function within (see articles list at: http://sce6938-01.fa00.fsu.edu/readings.html). While this literature offers a valuable starting base, we felt the perspectives represented needed to be transformed and elaborated on in order to be of most value in developing a framework for STS and a philosophical praxis. Some discussions led to these further and possibly missing considerations:

- developing more sophisticated and contextualized thinking (see Lawrence & Lambert, 2000),
- considering how STS would work based on limitations to agency in some cultures or on their expanded possibilities due to a communal orientations not typically present in Western cultures,
- looking at subtle differences in perspectives, i.e., local difference such as farming or urban communities, not just obvious worldview differences such as Native American vs. Western science views, and
- considering the limitations of current situated learning perspectives (Hildebrand, 1999) as well as taking postmodern theoretical perspectives into practice.

The nature of science also surfaced as difficult or minimally understood. However, in addition to understanding science as a cultural endeavor, as tentative, and so forth, an expanded view of what counts as science helps bridge STS in practice with worldviews, subculture considerations, and practicing science as inquiry with a science for all perspective. Short articles such as VonTobel's, "Two ways of knowing" (1989), and, Shurin and colleagues, "In defense of ecology" (2000) are good for provoking thought.

We had many interesting discussions focused on the nature of technology and its relationship to science and society, particularly on "What is technology", since everyone had a vision of technology as either computer technology or technical tools, but not an expanded vision which included technology as the human-made world, as design, nor as a social-cultural construct.

We considered what STS promotes that other perspectives, particularly in science education, do not promote. We talked about the critical aspects of an STS orientation...What

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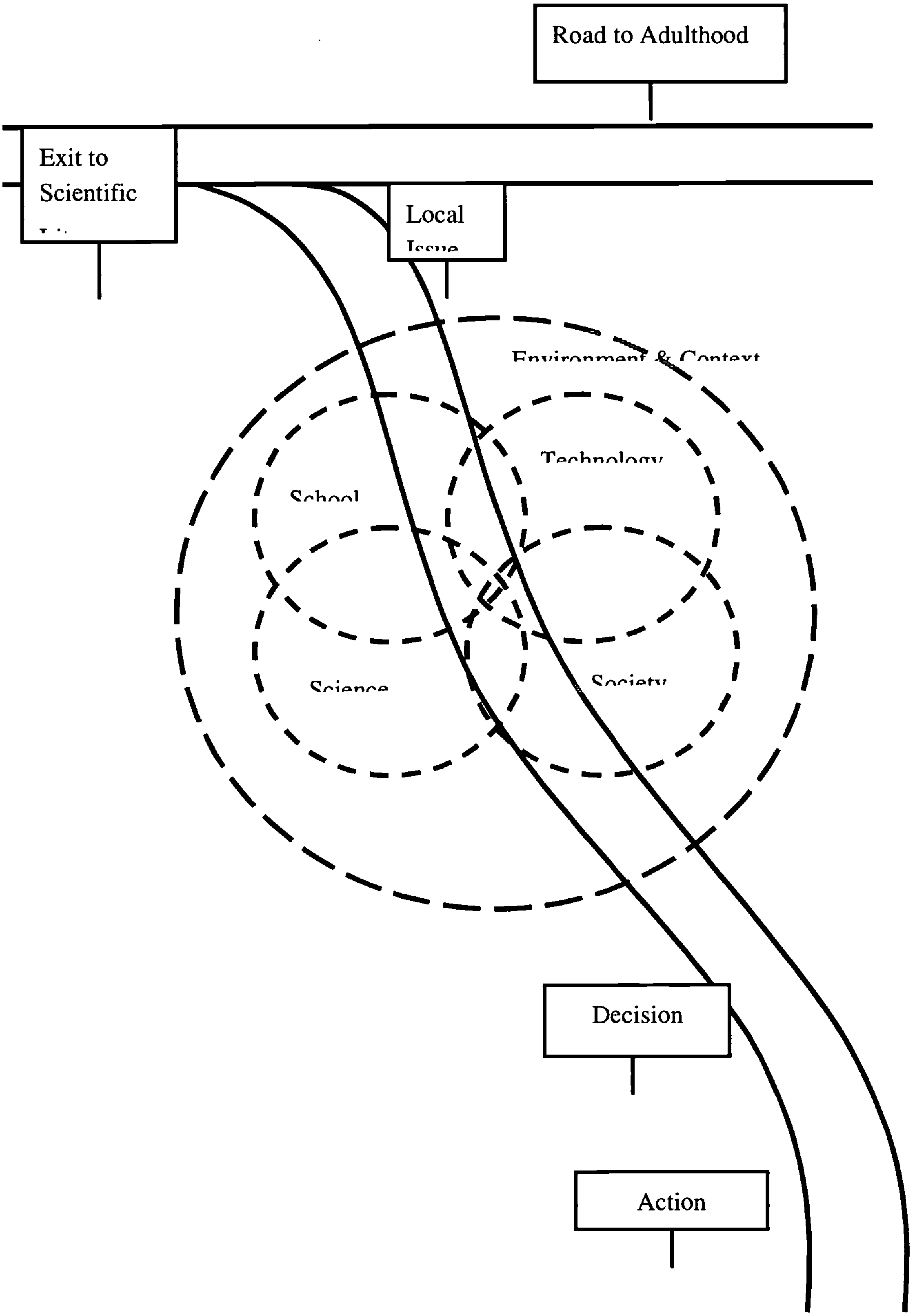
makes it STS?, Why is an STS orientation important?, and, How do STS orientations help integrate other perspectives and account for student needs, interests, and diversity while still learning science on a deeper level? Nearly every course participant said their understandings of STS turned a corner when reading Harms and Yager's (1981) list of critical aspects of STS orientations - seeing STS as a more encompassing perspective of curriculum and the underlying philosophy. Looking at the purposes of schooling and a "science for all" perspective led us to considering holistic development, especially from early through late adolescence. What emerged through discussion was a complex web of understandings that includes:

- developing personal agency (see Wells, 1998),
- honoring culture and providing scaffolding from one subculture to another (see Aikenhead, 1996 & 1999; Cajas,, 2000; Ogawa; 2000), and
- seeing students as integral parts of their community instead of as being schooled (see Lemke, 1994; Lesko, 1996).

Understandings of STS have universal features as well as being very personal and necessarily unique to each context; the school, the community, and the students. Over the semester, students progressively developed more sophisticated guiding frameworks of STS orientations to integrate key ideas (see Diagram 2) and their own areas of interest in STS (see Sowell, 2000 & 2001). We were concerned about certain trends in the classroom. A survey by Hancock (2000) asking teachers in Miami what they thought about STS, revealed the typical response was superficial understandings and classroom application, albeit positive. STS is seen

Diagram 2: Example of STS Framework



as simply being the "little boxes in text books" was often mentioned. STS has become an add-on in many classrooms, but not an orientation to the curriculum that is rich in the philosophy of schooling and theoretical notions about teaching and learning. The STS boxes and life relevance is often something mentioned during a unit but not experienced by classroom students in science. This understanding of STS could be akin to the problem with 'hands-on' labels, i.e., students are actively doing something, but it does not mean they are conducting inquiry nor are they thoughtfully engaged. We pondered if the popularity and adoption of more inquiry and problem-based learning approaches would solve the relevance problem and discussed whether these approaches are actually STS in disguise or so closely related it makes no difference. Our thoughts were that many other orientations do not consider the deeper issues related to curriculum but in practice appear to closely mirror STS orientations. However, they may not mirror STS orientations as closely on a broader and more holistic level or when looking over the curriculum.

Some students characterized STS orientations to the curriculum as a concrete example of the postmodern curriculum theory they had considered in-depth in other courses although STS seems to have a much more pragmatist or neo-pragmatist orientation – an orientation that is curiously not emphasized as postmodern by many proclaimed postmodernists. At its foundation, STS is future and idea oriented, concerned with both the community and the individual, and represents praxis much more than pure idealizing. If anything, those promoting STS have not proclaimed nor elaborated its strong basis in both philosophy and theory as much as they should.

We ended the semester, somewhat out of time, with discussions about thinking and some current theory on developing reasoning, contextual thinking, epistemologies, and ill-defined disciplines and problems. For me, the past two semesters have been a journey of reflection on my own teaching and research. I wondered if constructivism was enough to guide my teaching? While I still base my understandings of learning on basic constructivist assumptions, I spend more effort on developing situated experiences, community, and collaborations in my classroom and see 'ourselves' as a working group. I have given up the 'facilitator' role that always seemed inauthentic and passive for a role as a co-participant even though my role is as the leader or the group.

An Extended Community: Praxis and STS

Praxis in graduate courses necessarily means including 'practice' as an integral component – just as it would for a preservice teacher or a practicing teacher. While practice can refer to teaching in the classroom, it also has a larger meaning and includes those ideas we think of as professionalism - that of sharing and reflecting on one's practice through different means. I shared some of my burning concerns with graduate students and colleagues having tried integrating an STS perspective into science methods courses:

- Since these orientations involve much more student choice and self-direction, how can we help science teachers plan in flexibility and alternate paths into learning experiences?
- How can teachers learn to promote structure as a scaffold not a constraint on knowing and transition students into roles of greater agency and self-directedness over time?
- What kinds of qualities should teachers look to promote in students' thinking and how can these be promoted?

Often, I will share a concern in my teaching or just an idea with a graduate student because they offer a different point of view based on their unique experience. More importantly, because it engages them in the conversation of shared practice. It models being a reflective practitioner who

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doesn't have all the answers, who is constantly growing, and who honors their understandings and abilities. It helps us to build more sophisticated understandings together.

At the base of STS is community; students as part of their local community, community members as part of learning, teachers as part of their local and professional community, and classroom communities. At the University level, praxis in science education also involves seeing your practice as part of these communities and in building community with faculty in other disciplines and with other science educators. Last fall, several of our colloquium speakers intersected with our discussion of STS orientations; presentations by two school principles involved in progressive and whole school reform, a video on the nature of science and worldviews (the classic, 'Mindwalk'), a GLOBE presentation by a meteorology professor, a presentation on the language represented in science and feminist perspectives by an oceanography professor, and a presentation by another oceanography professor who teaches an environmental issues course. These perspectives were thought provoking and allowed graduate students to see that others' ideas are not all traditional, that we are not just idealizing from the ivory tower. And they could see that the ultimate goal is to eventually intersect with other members of the community as part of a working group.

Fortunately, three of my graduate students from last semester Scott Sowell, Elizabeth Hancock, and Yalcin Yalaki accepted the invitation to be a part of our interactive session at AETS, three that have helped me enlarge my own thinking and reflect on my own teaching. Together we talked about what questions could serve as focal points at AETS. Although the following section focuses on our AETS session, many other interactions with colleagues occurred before and after to help challenge our thinking and develop our understandings.

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Science/Technology/Society Orientations to the Curriculum

In opening our session at AETS, Bob Yager reminded us again that our primary focus is students, and we must honor and promote their curiosity about the world. All students have questions about their world, and science is about questioning and seeking that leads to developing investigations, evaluating the alternatives and evidence, and formulating new questions. We must be cognizant of how student curiosity is discouraged by much typical 'schooling'. Bob expressed his puzzlement at how anyone could be against STS as its basic definition is learning centered in the "context of the student as a person in a cultural/social environment (Harms & Yager, 1981)." Technology and science are never separated from our social world or world of work.

> Science is in use pervasively in our society. It is in use in the basement of the school building where the building engineer or custodian works with the heating system, the plumbing, the ventilation and air-conditioning, the electrical circuits that serve the building. It is in use behind the scenes at the museum in work on preservation and restoration, preparation of exhibits, and scientific research. It is in use at the local power plant, the local sewage treatment works, solid waste recycling center, transit system, auto repair shop, medical clinic, pharmacy, manufacturing plant, agricultural station. (Lemke, 1994, p. 1)

However, the deeper relevance of science and technology to even our daily lives and world of work is often elusive in the classroom as are developing students understandings.

> ...our curricula must work to insure greater continuity in students' ways of experiencing as they move from one classroom to another and from classroom to hallway to neighborhood to home (Lemke, in press-c). There is no more reason to believe that the habits of vital experiencing will automatically transfer to the rest of students' lives than that habits of technical reasoning will do so. What lasts for the longterm in us is what we have learned how to remake for ourselves across many contexts. This is not only an argument for more multi-disciplinary curricula, but for the curriculum to work more vigorously against the radical separation of school from the rest of students' lives. It is a very Deweyan concern.

In our discussions both before AETS and with session participants, we wondered what it takes to understand curriculum in this broader sense and teach from an STS orientation. Understanding the 'ideal STS' or the underlying assumptions of STS orientations is important to consider as a starting goal, something to strive for. Deeper understandings are needed to promote such learning at the university level and so teachers know where they might go even if they are under some constraints either in their personal understanding or because of curricular and school limitations and cannot accomplish the ideal.

Understanding the ideal also includes having deeper understandings of such underlying aspects as developing student agency in a developmental sense (not just motivation to learn science), conceptualizing and planning a living, dynamic curriculum overtime as well as on a daily basis, deep understandings of the nature of science and technology, and the intricate interplay between science, technology, and society. Classroom teachers and those promoting STS orientations in university level courses need a deep understanding of the underlying philosophy. This understanding takes place overtime, through practice and reflection. Unlike many other orientations, like problem-based learning, which do not seem to have a philosophical base, deeper understandings of STS orientations may require "a commitment to human welfare and progress" and philosophical positions that influence "all aspects of curriculum and teaching practices (Harms & Yager, 1981)

Group Discussion

Ideas about critical thinking and scientific reasoning skills surfaced repeatedly during our discussion and were agreed upon as important. However, such catch phrases can often mean different things to different people and are seldom attached to specific classroom practices. Herbert Their contributed the terminology "evidence based analysis" to sum up those catch

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phrases and to emphasize the skill of *analyzing* information using *evidence* that has been gathered and interpreted by the students themselves during STS units.

STS allows students to discover and interpret interrelationships within the natural world. This can be contrasted to a more traditional science classroom where science is distributed piece by piece, unconnected to the real world of the student. Since STS can establish a connection with the students' own lives, it is more likely that the goal of scientific literacy can be accomplished. Students will more readily incorporate science into their lives if it is presented in a manner comparable to their own personal subcultures.

An action component can often be the culminating activity for an STS unit. This activity stems from the students' growing expertise and agency about the issue being studied. However, it is important that the students remain the foci for the entire period. They should be in charge of how they take action with the science knowledge that they have established. It should remain personal and purposeful to them throughout the entire process.

By no means is an STS orientation to the curriculum an easy feat; it requires rigorous and authentic scientific work. It places a much higher responsibility on the teacher and the student. However, the benefits are in line with current science education reforms.

Teachers must create a unique classroom community in order facilitate an optimal STS experience. Students, as mentioned before, should be the foci of the entire unit of study. Their classroom should be a safe environment where they feel comfortable taking risks and asking questions. It should be a "personal classroom" where collaboration and communication are valued commodities. As one member of our group put it, you would like to hear "my brain hurts" kinds of conversations going on between students. We felt that students should be expected to support their opinions during discussion, and that through this type of discourse, new

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connections could be made for the entire class. Research into dialogue and discourse (Wells, 1998) could enrich our understanding by being incorporated into this developing theoretical framework of STS.

Students should feel that they are a part of an important, learning community; one that is actively involved in something meaningful, purposeful and relevant. They should be able to feel the connection with the local community outside of the school walls. That is where they live and that is where their scientific literacy will eventually be expressed. The more human interaction with each other and with the outside community, the more the science feels real and useful. STS has the ability to take independent, fragile knowledge and cradle it within a valuable, living context.

The definition of the word "curriculum" also surfaced during our conversation about STS. If STS is to broaden our way of thinking/teaching/learning science into a more humanistic and holistic manner, so should our view of curriculum. Instead of a list of facts that should be covered, the term "curriculum" should also be holistic, including the relationships between teachers and students (and between students and students) and how these relationships affect the learning within the classroom.

Being innately interdisciplinary is one of STS's greatest strength. It is seldom that science or scientific thinking exists in isolation in the real world. So why should it be taught in isolation in the classroom? Since STS involves students in authentic scientific issues, it draws clear connections to math, language arts, social studies, performing arts, computers, etc.

Some teachers are reticent to try STS in their classrooms. The inner life of the teacher and their reflective journey overtime is of the greatest importance. It is a journey that is simultaneously individual, social and collegial; a journey much more difficult than just

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understanding inquiry or being able to transform science into exciting learning experiences. We believe that to more fully understand STS orientations, how they are promoted in different contexts, and to develop the foci of research, we will need more science educators at all levels able to engage in praxis

Interior Activities: What Must A Teacher Consider When Adopting an STS Orientation?

Working from an understanding that STS teachers act as individuals in unique contexts, teacher educators seeking the adoption of an STS orientation among their students must consider the following question: What must a teacher consider when adopting an STS orientation?

The few teacher accounts (McLaren, Yorks, Yukish, Ditty, Rubba, & Wiesenmayer, 1994; Jeffyres, 1998) that exist form the beginnings of an image of what teachers must consider and do in order to implement STS: laying out broad questions, establishing a flexible framework for learning experiences, and giving students agency and voice in the evolution of those learning experiences.

Research that focuses on the work of STS teachers (McGinnis & Simmons, 1999; Mitchener & Anderson, 1989; Pedretti, 1996) reveals many important issues. The pressure to cover content, whether it is perceived or real, presents a serious limitation to STS implementation. A teacher's understanding of her students, the school context, and the community norms is vital to creation of successful STS education. STS teachers must work from a carefully considered, personal vision of their work and STS.

The suggestions made by researchers and theorists in STS education (Ajeyalemi, 1993; Bybee, 1991; Rubba, 1991; Waks, 1992; Williams, 1994) focus on the interior activities and dialectical relations of STS teachers. The interior activities of STS teachers should include establishing one's own theoretical position on science and teaching, planning for instruction, and

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attending to the role of students in the learning experience. STS teachers maintain a dialectic with resources, other teachers, and students.

In summary, when developing theoretical positions STS teachers must consider the role of students in the planning process and learning experiences; insure their understanding of the students, the school context, and the community norms; develop a flexible framework for learning and establish broad questions to guide the learning.

There are other considerations for STS teachers that have not been explored in the literature described above. Viewing classrooms as sites of culture creation (Aikenhead, 1996; Levinson & Holland, 1996) has important implications for STS education. STS teachers must consider their own beliefs and values related to societal issues and the impact those beliefs and values have on the act of teaching.

Group Discussion

Our group addressed the question: What must a teacher consider when adopting an STS orientation? And, to clarify the following elements of this issue: teacher beliefs/theoretical framework, contexts, student role, and planning/organization. We focused our conversation on consideration of the categories that emerged in the literature introduced above: beliefs and theoretical frames, planning and organization, student agency, interacting contexts, and experiences.

Within the realm of beliefs and theoretical frames, a teacher adopting an STS orientation must articulate her notions of epistemology and pedagogy with particular attention to the cognitive abilities and learning styles of her students. The teacher must address the nature of science with a particular focus on inquiry, the relationship between science and culture, and non-Western notions of science. Since the ideal implementation of STS includes social action,

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teachers must consider their position on political, social and ethical issues and the relationship of these issues to science.

The development of beliefs and theoretical frames is intimately linked to the experiences of the teacher prior to his entry in a teacher education program, as a pre-service teacher, and as an in-service teacher. We believe it is vital that teachers experience STS as students in their own science coursework. Achieving this demands the thoughtful involvement of science faculty. The literature on teachers involved in STS instruction does not introduce experiences such as risk taking, participation in social action, involvement with politics, and tackling of controversial issues. We feel that these experiences may be vital to an STS teacher's exploration of social issues and pursuit of social action.

When considering preparations for STS instruction, the teacher will need to develop a flexible framework that balances student agency and professional obligations. The teacher will also need to consider the balance among the science, technology, and social elements of an STS orientation. High quality STS preparations will almost certainly involve dialectic interactions with other content teachers and members of the communities within which the school is situated.

These communities are part of the interacting contexts that an STS teacher must develop an awareness of and consider student engagement with. These contexts include the school, science, society, and the community. Beyond the school and local contexts are regional contexts that influence and are influenced by the local issues pursued by students. AN STS teacher must also recognize that these interacting contexts have unique cultures and that students bring their own worldview to their interactions with these cultures. Learning experiences that move among these interacting contexts are limited by the institutional structures of schools and school systems. This is particularly evident in concerns over accountability and covering content.

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Considerations related directly to student agency did not emerge in our conversation. During our conversation it was suggested that experience is a key in facilitating teacher adoption of an STS orientation. It was also suggested that the notion of interacting contexts is unique to STS and should be a key focal point in educating science teachers.

Much research is needed on how we can help beginning teachers, either already in the classroom or in preservice science education programs, transition towards STS orientations. Understanding how to develop inquiry lessons, question students, promote collaborative learning, and so forth maybe a start, but does not constitute an STS orientation. Typical science education methods courses do not help preservice science teachers understand how to develop integrated and extended units in the classroom or think about holistic student development and curriculum on a broader level. It is even more difficult to give preservice science teachers experiences in teaching something more than "by the lesson plan" prior to entering teaching. Some programs, such as the Iowa based Scope, Sequence, and Coordination program have provided excellent professional development models to scaffold practicing teachers in learning STS orientations and directly apply what they have learned in their own classrooms. We need more of such programs so that practicing teachers can work in conjunction with science education faculty to help scaffold preservice and new science teachers, provide a collaborative and supportive community, and supply teachers who can be powerful spokespeople in their districts and in science education professional research and teaching communities. There is much we do not know about how new science teachers come to understand and implement STS orientations particularly given that they all enter at different place, with different understandings, and will teach in diverse contexts.

Transitioning: How do Teachers Make Transitions to STS Teaching?

Science teaching is a spectrum of approaches that extends from traditional to STS. We believe traditional ways of teaching and teaching from an STS perspective are the two extremes of this spectrum. A few of the most striking differences between these extremes identified by Hurd (1981) are presented in Table 1.

Table 1: Traditional vs. STS Orientations

Traditional Orientations	STS Orientations
Teachers and textbooks are the main sources of knowledge	Students actively seek information to use
Science is abstract and has no relation to technology or daily life	Students see science as a way of dealing with problems in everyday life
Students concentrate on problems that are identified by the teacher or textbooks	Students identify problems about themselves or their community and take responsibility to solve those problems by using science
Minimal consideration given to human adaptive capacities	Human adaptation and alternative futures emphasized
Value-free interpretation of discipline bound problems	Value, ethical, and moral dimensions of problems and issues considered
Curriculum is textbook centered, inflexible; only scientific valid is considered (and from a limited view of content)	Curriculum is problem centered, flexible and culturally as well as scientifically valid
Information is in the context of the logic and structure of the discipline	Information is in the context of the student as a person in a cultural/social environment

The list for these differences is much longer of course. It is clear that for a teacher who uses a traditional approach in his/her teaching or for a pre-service teacher who received a

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traditional education throughout her life, it is not easy to shift to an STS approach in a short time. Many teachers may integrate some facets of STS in their teaching or incorporate inquiry as an important experience, however, they also face a transition into STS teaching. In other words, each pre-service or in-service teacher brings different understandings and starts from different points of entry. There should be a time period in which the teachers take conscious and cautious steps toward an STS approach, if they see any value to it (Figure 1).

The questions are, "How should those steps be taken?" And, "How can we find different avenues into developing further understandings of STS orientations and implementing it in classroom practice?" Given an ideal situation, "What is the nature of these avenues?" What process or major steps have others in this group gone through or helped pre-service/in-service teachers go through? What are important considerations in helping to promote this change?

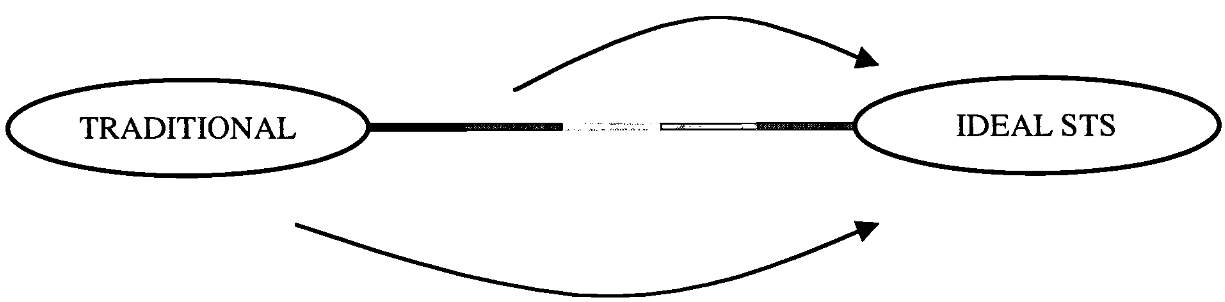

Figure 1: Transitioning Toward STS Orientations: Pathways

Instructional techniques for STS education include developing simulations, cooperative and collaborative approaches, inquiry based learning, independent projects, small group discussions, case studies, surveys, oral presentations and written reports. However, teachers should understand that STS is not only about applying some of these approaches. STS is more about, as May (1992) puts it,

> ...promoting an ecological, moral, cultural, pluralistic, and spiritual perspective, an "ethic of caring," and a critical pragmatism based on contingencies that make our decisions and tasks all the more complex but necessary if we are to create a better world for ourselves. (p. 81)

Science teachers are the most important (but not only) key in shifting toward STS education. Therefore, for a successful shift to occur, science teachers has to have a very complete understanding of what STS education is about and the philosophy behind it. They also need support and help from other people who involved in education. According to Heath (1992),

> Many good STS units and programs result from individual teachers striking out on their own filled with enthusiasm, ability, and dedication to the importance of STS, but with little support. Without support, it is difficult to expend or maintain the quality of ongoing STS instruction. Technology, interdisciplinary teacher teams, partnership with universities could be sources for support. (p. 52)

Rubba (1991) suggests that, STS has not attained the level of implementation recommended by NSTA because the majority of the science teachers are not prepared to teach STS. Before STS teaching practices can be fully developed and put into practice appropriately, science teachers' beliefs and values about science education must be restructured in such way that, they can fully appreciate what the notion of responsible citizen action on STS issues as a goal of a school science education.

In the literature there are suggestions about the transition toward an STS orientation. For example Rubba (1991) suggests a project approach, which refers to STS issue investigation and action instruction, as one model of STS instruction. This approach consists of 4-6 week units that can be made part of a science course.

Heath (1992) suggests that most common approach to STS instruction appears to be infusing STS themes into science or social studies courses at the middle or high school level. This is done by developing new units, modifying or extending existing units with new materials and activities. Developing new STS courses is another approach for STS instruction.

Pedretti (1996) also suggest that infusing STS material, modules or units into existing courses is a more supported way of initiating STS education into school curriculum than developing separate STS courses.

Group Discussion

One of the main ideas that came out in our group discussion was that a transition toward STS education takes time and requires determination. Students need to be prepared for STS education and for the kind of assessment that is going to be used. The control over students' learning should be slowly shifted to the students themselves. Instead of answering every question that students ask, new questions should be asked of them in order to make them think and come up with their own answers and make their own decisions.

Another main idea was that short time experiences might be useful during the transition toward STS education. For example, open-ended STS activities, embedded into science curriculum as STS units, could be the context of these short time experiences. After such STS activities a discussion with students about the activity, talking about what worked well and what didn't, analyzing the roles of students and teachers in these STS activities may help to improve future activities. If there are enough resources, STS courses can be designed after experimental short time experiences with STS activities in science classes. Bob Yager suggested that:

> One of the best ways for teachers to move to STS teaching is to involve them in a discussion about some current issue - one currently in the news. This situation can lead to questions, to needs for interaction, to interactions with experts from written word or in person. All of this leads to interactions that can be used in

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dealing with the issues. Many teachers can be involved with such activities and conversations - and then think about doing it with students. Teachers need to identify what they did. What they learned, and how they used their learning. Then the question can be posed. What prevents you from trying such an approach with your students - for one class period or a month? Then analyze what happened with the students. Let them propose how to develop even bigger and more complicated issues to consider.

Many new STS teachers can tell of stories about how their students reacted. Many can provide evidence of what their students did and how they learned to resolve such issues. They often become 'experts' and enjoy their 'knowing' and the use of it. This is central to an STS investigation. It's an odd situation, both teachers and students often forget what they have learned as they are engaged with the issue.

One of the other issues that we talked about in our discussion group was the availability of support to the teachers who want to implement STS education. Administrative and parental support is important in implementing STS into the science curriculum. If administrations in schools and parents become familiar with STS education and its potentials, they may be more willing to support STS education and the teachers who are trying to implement it. Student presentations to demonstrate their accomplishments in STS activities may be helpful to familiarize administrators and parents with STS education.

In brief, the main points that came out from our discussion were that, any transition to STS education is not a simple process. It requires patience, determination, time and good planning. It is important to inform students about what STS is and how the instruction will change with STS. Teachers need to proceed toward STS education step by step experimenting with short STS activities and use these experiences for developing more comprehensive STS units. Teachers also need to get support from school administrations and parents. They can do so by providing information about STS education and trying to explain the advantages of STS to administrations and parents.

Implications and Future Directions

STS, Culture and Community

Our discussions highlighted a number of considerations, which we would like to probe more deeply. Aikenhead (1996) describes learning science as culture acquisition, where culture includes concepts of norms, values, beliefs, expectations, communication, social structures, customs, worldviews, and technology. He advocates an approach to science education that assists students in making smooth crossings of the borders of their culture, society, science, technology, and the culture of school. Levinson and Holland (1996) describe culture as continually being created and changed. Classrooms have cultures of their own, which are being created by the teacher and students. Given this, it may be more appropriate to see science education through an STS perspective as the creation of a culture and a community. The students and teacher create the norms, expectations, communication, and boundaries together. From this perspective, a teacher must consider the kind of culture she would like to create, how she will create it, and what role the students play in the creation of that culture.

Previous research in science education has encouraged teachers to consider their students' sociocultural worlds to enhance the quality of classroom instruction. (Aikenhead, 1996; Aikenhead & Jegede, 1999; Brown et al, 1989; Cobern, 1996; Costa, 1995; Hawkins & Pea, 1987; Waldrip & Taylor, 1999)

Cobern (1996) cites worldview when addressing the current reform measures on scientific literacy:

> ...all the definitions of scientific literacy include the embrace and application of science in everyday life – but one will apply science only when it fits one's sense of self and environment, personal goals, and understanding of how the world *really* is – in short, if one has a scientifically compatible worldview. (p.586)

Teaching from an STS perspective in a school context is a complex task. In order to facilitate more widespread implementation of fully realized STS education; teachers, educators, scientists, and researchers must collaboratively address the following questions:

- What is the relationship between contexts and implementation of STS?
- What role can teachers play in mediating contexts unfriendly to STS?
- What support exists within the science community for STS education?
- What STS science experiences are appropriate for teachers intending to implement STS in their own work?
- What are the experiences of STS teachers?
- What are the implications of the classroom-as-site-of-cultural-creation perspective?
- How do STS teachers deal with the relationship between their personal beliefs and their teaching?
- What does student agency look like?

We end our discussion with an appropriate quote from *Blueprints for Reform* for *Project 2061* (AAAS , 1997) on recognizing the power and importance of using teachers for curriculum reform and their intimate involvement in any successful and shared praxis:

> The most effective curriculum connections are designed at the school by people directly involved with the school: stamped-out curricula tied to written-to-formula textbooks have served teachers and students notoriously poorly in the past. Even if we disregard the growing sentiment that teachers and administrators must be given the freedom to design instruction relevant to their students, the resistance of many teachers to top-down mandates implies that those implementing science education reform must drive its local design and application.

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STS and Social Advocacy: Citical Issues (by Paul Jablon)

After 31 years of classroom teaching and working with prospective science teachers in the university environment the following is clear to my science education colleagues. Most people who have decided to become science teachers envision themselves simply engaging adolescents in the "wonders of science" that they themselves are so enamored with and soon find that for a majority of their students the beauty and discovery of science is not as compelling. This is true even for those teachers who engage their students in daily inquiry-based, hands-on, minds-on investigations. The same format for science education that worked so well with elementary students no longer has the same level of success with adolescents.

When presented with the possibilities of engaging their students in knowing science through the avenue of technology and societal issues a small percentage of the science teachers cautiously examine these STS materials. Of those that piloted this approach only a small percentage continue to use this approach as the focus for their teaching, despite their realization that many students previously disengaged become very motivated to learn science to respond to ethical societal decision making, mostly related to the utilization of technology.

It has been my experience that the ones most engaged in the use of the STS materials, and who use them most effectively with their students, were previously involved in social advocacy activities outside of teaching. These social advocacy issues were not necessarily science related, such as environmental or medical ethics, but many times dealt with poverty, racism and other social justice issues. This only makes sense as much of STS-oriented curricula are based in making social science and philosophical evaluations. Not only does it mean being comfortable with the format of this decision making, but also comfortable in leading groups of individuals from diverse backgrounds in making their own evidence-based decisions.

This leads to the need for both inservice and preservice orientation of science teachers in the facilitation skills and understanding of the ethical and philosophical frameworks in which this social science decision making occurs. Otherwise it is not fair to expect science teachers to embrace STS teaching regardless of its proven effectiveness.

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