

TeamStorms as a Theory of Instruction

Matt Jadud

TeamStorms is a team-centered, problem solving based approach to learning, stressing active participation on the part of the learner in a constructivist learning environment.

Introduction

HISTORY

The theory of instruction presented here represents my attempt to formalize the methods I have instantiated and evolved over the past year-and-a-half in the classroom. Beginning in the Spring semester of 1999, I ran a series of laboratories for students within the *A110: Introduction to Computing* curriculum at Indiana University, Bloomington. These laboratories made use of the LEGO Mindstorms Robotics Invention System, which we (the students and I) used to explore the fundamentals of robotics and programming together. TeamStorms, as it is presented here, was implemented in a rough form, being developed and revised as the semester progressed. During the summer of 1999, *Q515: Learning with LEGO Robots* was co-taught with Tom Keating in the School of Education at IUB, then faculty at Indiana University. Here, the instructional method was implemented and discussed in class, as pre-service and in-service teachers explored how they might use similar techniques in their own classrooms. The Fall 1999 semester saw the implementation of TeamStorms again in A110, more refined and more fully developed; this document was written up concurrently with this most recent instantiation, and both the writing of the theory and classroom experiences from this semester influenced each-other.

The Spring 2000 semester will be the first time TeamStorms is used in a course of its own, when *A290: Introduction to LEGO Robotics* is offered in the Department of Computer Science at IUB. This 2 credit hour course, being offered on a provisional basis, will give students the opportunity to explore robotics, programming, artificial intelligence, machine learning, and the influence of robotics in society in a way that I believe opens up learning in these areas to students who are typically discriminated against because of a lack of mathematical ability. I believe the instructional approach being used is largely responsible for this accessibility.

ABOUT THIS DOCUMENT

This document has been organized, as much as possible, to aid instructors in making use of it as a resource for implementing TeamStorms in their own classroom. *Large, italicized, underlined headings* denote the larger methods of TeamStorms. Under these headings come **SIDEHEADS IN BOLD CAPS**, which denote kinds of instruction under the larger heading. Lastly, *italicized headings* sized no larger than the body text denote subkinds, and situations and methods for implementing or dealing with them are then discussed underneath them. Lastly, text that is boxed off in gray is separate from the flow of the body text, presenting examples of how TeamStorms has and will continue to be implemented. This is presented as additional material for instructors interested in implementing the methods described here.

Values and Goals

The values and goals presented here are those that an instructor implementing TeamStorms should attempt to take to heart, and use as guides when the detail laid out in the rest of this document is not enough.

VALUES

1. Students should be responsible for their learning (individually and from each-other) whenever possible.
2. The process is often as important as, if not more important than, the product.
3. Exploration, on the part of the students and instructor, is important; sometimes, neither will know the “right” answer.
4. Students should be encouraged to work and learn from each-other; group work is, generally, a *good thing*.
5. Learning should be fun.
6. Learning situations authentic to the material being covered, or better yet, the students’ world, are better than hypothetical or far-away examples and situations.

GOALS

1. Students should learn to learn.
2. Students should get a sense for how to effectively work in teams.
3. Students should learn to use tools overcome challenges and problems.
4. Students should learn to not let frustration stand in the way of success.

Formulation of Module Objectives

While the formulation of objectives for a given lesson or module may tend to be more of a design issue than an issue of instructional theory, I anticipate that instructors implementing TeamStorms will be charting new territory, and as such will be designing some of their own materials. This section is provided as guidance for choosing good knowledge and process objectives for a given module or lesson.

A module or lesson might be anywhere from one to three laboratories in length. An instructor runs the risk of losing student interest if a single lesson is dragged out for too long; some judgement will need to be used in gauging what constitutes the right number of knowledge and process objectives for one lesson, based on the instructor's target audience.

Knowledge Objectives

In deciding on the knowledge objectives for a lesson, an instructor will want to keep in mind that TeamStorms is, whenever possible, an *active approach to learning*. Therefore, knowledge objectives come in two kinds: those provided to the students, and those researched or discovered by the students.

PASSIVE KNOWLEDGE OBJECTIVES

Passive knowledge objectives are those where the student needs to do some sort of research that does not require them to actively engage the material (and produce something through their labors), but instead simply 'learn' material for later use. Common resources for achieving passive knowledge objectives include various print media (newspaper and magazine articles), the WWW, and video recordings or movies.

Utilizing print-based media

Print-based media, while very prolific, should be used judiciously. Reading is typically a very inactive process, as students do not usually have good study and reading skills. An instructor planning on using articles or texts as primary resources for students should be prepared to support students in utilizing these resources effectively: demonstrating how to take good notes while reading, how to highlight key points in a paragraph, and generally recognize the important points in an article or chapter.

Not all Text is Textbook

In *A290: Introduction to LEGO Robotics*, there were no suitable texts to be found that were affordable, dealt with real issues in robotics, and the philosophical issues of machine learning and artificial intelligence as well. Given this, a textbook was not an option; however, short stories by Isaac Asimov will be used throughout the course because they deal with problems and challenges that come up when human-like robots and humans interact on a daily basis. Set in a future that comes ever closer, these stories are thought-provoking, enjoyable, and generally short. This allows for research and articles from the discipline to be easily interspersed with the class text, while maintaining thematic flow throughout the semester.

Utilizing Web-based media

The Web is an incredible research tool in some respects, and a nightmare in others. The most common interface students will find to the Web today is a *search engine*, which indexes content based solely on the words found in a web page. Learning to search effectively is a non-trivial task, and an instructor should provide URLs (or addresses) to web pages whenever possible.

Web-based media is as dangerous as print-based media in many respects, except students may not have as much access as an instructor might like to the material. Also, because of the very thing that makes web-based media so attractive (the ability to embed hyperlinks to other pages), students might get drawn away from the material at hand without realizing it.

In short, web pages are a curse and a blessing for use by students attempting to gather knowledge in preparation for a lesson. If they do not have good reading and study skills to begin with, then the web will perhaps only present more distraction than support, and do nothing to enhance the learning process.

Audio-visuals and video based materials

Students today are very visually oriented; as a reference, college students graduating today grew up with MTV and Nickelodeon. The Nintendo is a part of their normal existence, as was the Game Boy and similar video game consoles. As such, TV and other electronic media may prove to be informational sources that students will relate to more easily than text-based media.

Movies and TV sources can take many forms. An instructor might choose a purely informative resource. These should be used with caution, as such resources tend to be inauthentic and dry; this kind of instructional aid will not hold students' attention spans. Sources which are traditionally considered for entertainment only can also be of use, and should not be excluded because of the fact that they were not designed for "educational use". Movies and serial television programs often focus on some moral or ethical issue, and science fiction (especially) focuses on the issues surrounding technology and its role in society. Using parts of these sources (key scenes or episodes), or entire movies can be used with great effectiveness for reaching students today.

Using AV Resources

In *A290: Introduction to LEGO Robotics*, several possible audio/visual resources are being considered. One is an excellent documentary on the history of robotics since the late 60's. This documentary is well done, but it is just that - a documentary. Because the course is also interested in dealing with the impact of robotics on society, the movie *Bicentennial Man* starring Robin Williams, based on the short story of the same name by Isaac Asimov, may be used. This movie, while produced for entertainment purposes, deals with the question of how we handle a robot that wishes to be human, and what happens when the technology exists to make a robot that looks, talks, and thinks just like a person.

ACTIVE KNOWLEDGE OBJECTIVES

Active knowledge objectives differ from passive objectives in one critical way: they are developed or discovered by the students in the process of doing their work, and not spelled out in advance by the instructor. An instructor might plan a lesson such that some knowledge is necessary to complete the assignment. Instructors may choose to alert students to the fact that some research may need to be done to complete the module, or perhaps the instructor will choose to simply see how students fare.

This is a break from many traditional forms of instruction, where students are given all the knowledge they need for a lesson up front, either in the form of generalities that attempt to capture a wide category of problems or situations, or one example which the instructor feels is particularly appropriate. When students get stuck, the instructor still might have articles or WWW addresses ready for students to make use of (in the event that they are unable to find the resources themselves), thus assuring that the learning process does not get hung up over the lack of one key piece of information.

Thinking about Programming

One of the difficult things for students to realize when they first begin programming robots and free-roaming creatures is that the machine will do *exactly* what they tell it to. When dealing with issues of concurrency (more than one program executing simultaneously), this can become even more confusing.

To introduce students to this concept, instead of lecturing and attempting to illustrate the issues at hand, a favorite Thinkorithm of mine is to have students write down all the steps involved in tying one's shoes. They should assume that the person reading their instructions has grown up with Velcro, and has never had to tie a pair of shoes before. Then, as a class, students read their instructions to me while I attempt to follow them explicitly. What often results are a pair of untied shoes.

Here, the students are forced to think about things they normally take for granted, and with robotics work, the same thing must be done in programming. The point is illustrated in a much more memorable and concrete way through the use of the Thinkorithm than any amount of lecture might accomplish.

Process Objectives

The process skills the instructor hopes for the student to develop often have wide-ranging application, and therefore their placement and timing in the instruction can have a very strong impact on how the students handle new material and situations. Unlike knowledge objectives, it is unlikely that an instructor can cover for missing process skills with Mini-Lecture, reading, or video-based instruction. Careful ordering of the process objectives so they build in a logical manner upon each other is therefore a very important part of choosing and placing the process objectives for a lesson.

PASSIVE PROCESS OBJECTIVES

“Passive process objectives” may seem like an oxymoron at first, but it is possible to cover process skills in a non-active way.

Reading about or watching processes in action

Students might learn some process through reading about or watching the process skill. While this is not authentic, it may sometimes be the only way for students to learn a pro-

cess before putting it into practice, either because of limited time, equipment, or materials.

Typical Computer Programming Texts

Typically, every programming text on the market falls into this category. Students are led to believe simply by the sheer proliferation of such texts that one can learn to program from a book; this is, of course, false. Many students of math suffer from the same delusion. Occasionally, one can find a text that forces the students to play an active part in their learning, but not often.

Real-World Analogies

There are processes the instructor may want the students may be able to be connected through some analogy to a process the students are very familiar with in the real world. When possible, grounding abstract processes in the real world is preferred, as students then have something to relate to, and an existing knowledge base to draw upon.

**ACTIVE PROCESS
OBJECTIVES**

Active process objectives are typically achieved fairly easily by assigning students tasks that require a particular process to be put into practice. This kind of authentic instruction is particularly valued by the TeamStorms approach, and is preferred to the more passive approaches discussed above.

An active process may be discussed or studied in advance in some way by the students, perhaps best developed as part of a Thinkorithm or Natural Consideration.¹ If the process is not studied in advance, and left to be discovered by the students, the instructor should be prepared to guide the students as they attempt to complete the module so they learn the processes involved properly. Improperly learned processes or poorly learned processes can have lasting ramifications for students, and as such the instructor should take care to design active learning situations carefully, or be prepared to catch erroneous or misconceived processes so as to correct students early on.

Example-Practice

Processes can also be taught through the well known model of example and practice. While this approach does not encourage the students to develop their own understanding of the material, there are times when it is better than any other approach.

Synthesis of Ideas

Another approach is to present students with what I like to think of as a toolbox, or perhaps better yet, a “box of stuff.” There are many problems in the world for which there is more than one solution, and more than one tool (or combination of tools) which is appropriate. Problems of this nature are sometimes put to students as if they were stranded on an island, a raft at sea, or some other constrained scenario. By bringing together the tools and ideas at hand, new solutions and ideas might be developed.

1. Both are discussed later in this paper.

Thinkorithms

Learning through self-reflection

In learning about problem-solving techniques, students might be encouraged to describe in as much detail as possible the process they went through to solve a problem. Many tasks may benefit from self-reflection as a means for learning a process more completely. The instructor might provide scaffolding for the students in this process by generating a list of questions the students could consider, or perhaps giving an example of the kind of narrative the students might generate as they reflect on the processes they went through.

The Use of Journals

In A290, the typical lab book is being replaced with what will be referred to as a “problem-solving journal.” Traditional lab books in physics and chemistry ask students to detail their laboratory in painful detail. What I want is for students to document the part of the process I cannot see - how they approached a problem, what they were thinking before, during, and after their attempt(s), and where and how they got stuck. This will prove to be more valuable to me and the students in the long run, I believe.

Thinkorithms

A “Thinkorithm” can be considered either a “Thinking Algorithm,” or involves “Thinking about Algorithms.” To rephrase this in other terms, Thinkorithms explore processes: these might be naturally occurring processes (like the water cycle), or artificial processes (like the steps taken by an airline pilot preparing for take-off).

Thinkorithms play important roles in the TeamStorms theory of instruction, as they provide an *active background* to the material students will encounter in the module. Where many pre-lab exercises require students to read and (perhaps) answer questions, Thinkorithms require that students solve problems or brainstorm ideas related to the material they will face in the module, without actually tackling the core problems or challenges to be faced in the module itself.

MEETING KNOWLEDGE OBJECTIVES

When preparing a Thinkorithm, the instructor should consider the knowledge goals for the lesson, and examine which should be presented as part of the lesson, and which would best be learned by the students before entering the classroom. Knowledge students should come to the classroom with might best be placed in the path of a Thinkorithm. Put another way, an instructor might design a Thinkorithm that will require students to learn (either through research, the instructor, or other students) some key fact or facts to complete the problem presented to them.

MEETING PROCESS OBJECTIVES

Like knowledge objectives, Thinkorithms can be designed to meet some process objectives for a lesson, or perhaps introduce students to the processes they will be expected to use in the module or lesson at hand. Another approach might be to have the students

Thinkorithms

tackle some problem that will require a similar or related process, thus preparing them to handle the active process objectives for the lesson.

SHOULD BE FUN

A Thinkorithm need not be dry; students encounter dry thought problems in mathematics, physics, and chemistry on a routine basis. This may be one of the problems with these fields already, is that students are inundated with boring, repetitive work. Novelty in the Thinkorithms, where possible, is a good thing. Making the Thinkorithm a contest or game is one option, as long as the instructor remembers that only one student need not win - many students can all 'win,' and still they will be motivated by a certain competitive spirit. Tying the Thinkorithm into the students' daily lives can also be a powerful motivator, and make it even more enjoyable to the individual. The notion of providing a valuable service, or solving practical problems for many students is more important than solving abstract, unrelated problems.

SHOULD ALLOW FOR CREATIVITY

Problem-solving processes are not cut-and-dried. This being the case, the Thinkorithm should provide an outlet for student creativity, and encourage students to think freely when trying to solve problems put forth in a Thinkorithm. Students will likely be more interested in attacking the problem if they are free to approach it in their own way, from an angle they are more familiar with, and therefore more likely to explore than if they are forced to work in a domain they are unfamiliar or uncomfortable with.

SHOULD BE OPEN-ENDED

Thinkorithms can be open-ended. There is nothing that says a Thinkorithm must have one right answer, or that there is a good answer at all. Given that many problems students will face in the world today are not simple, and have no clear answers, learning to deal with that fact early on is a valuable realization to make. Open-ended Thinkorithms should be discussed and developed further in either a full-class or small group setting. This is necessary, as any problem presented to the students that does not have one single, good answer should be more fully developed and discussed, so the process involved in attempting to develop good solutions can be drawn out fully by the students and instructor.

SHOULD BE ACCESSIBLE

The instructor should not be afraid to provide additional knowledge or context to the problem to aid students as they tackle the Thinkorithm. This information may be presented as a story, as straight facts, simple pointers or URLs to places where students might find more information, or perhaps video or TV sources.

Regardless of whether additional information is required or not, the problem itself should be *accessible* to all students. Accessible means that the problem, as stated, can be

Natural Considerations

easily grasped by all students without additional learning or research. Furthermore, it should be presented in a way that makes sense to all students involved.

The “Travelling Salesman” Problem

The travelling salesman problem is the classic problem of finding the shortest route through a number of cities that a salesman must visit. This problem is NP complete, meaning it is impossible, regardless of the amount of computing power available, to solve this problem in an amount of time that is linear with respect to the number of cities the salesman must visit. It could be discussed in terms of graph theory, topology, or the analysis of algorithms, all of which are areas of study few people are familiar with.

Despite this, the problem of finding the shortest route from home, to the grocery, to the library, the music store, a friends house, to the movies, and back home, is a process that many students could tackle. This problem falls into a class of problems whose very nature stumps Ph.D.-level researchers even today. Because the problem is challenging or fundamentally difficult does not mean that it must be presented in a manner that makes it inaccessible to some or all of the students involved.

SHOULD BE CHALLENGING

While it has been stated before, the fact that the Thinkorithm should be challenging is important. This could mean “puzzle-like,” perhaps in a fairly straight-forward or devious way. The Thinkorithm should definitely challenge the students either in their ability to think creatively, or critically, or push students’ abilities to evaluate their own thoughts. The problem may be too difficult for the students to actually accomplish, but the process should not be so difficult as to not allow them to achieve anything.

Pathfinding and Mazes

One of my favorite challenges involves building robots that follow paths or lines. The students are equipped with a simple “eye” that can see shades of gray - and only one pixel of it, at that! Given this limited “eye,” how can they build a robot that follows a path? Among other Thinkorithms, I present them with the challenge of coming up with a set of rules for finding a way out of a maze - any maze, any time, with the same set of rules. This is not as simple as it seems, but is one step towards solving the problem of line following with a one-bit light sensor!

Natural Considerations

An important part of exploring new material is researching some of what has come before, or at least grounding the new material in the body of existing knowledge. Because of the importance of grounding the abstract in the concrete, and the cross-disciplinary nature of TeamStorms as a theory of instruction, tying the abstract process into some natural process is a good way to get at many abstract concepts in math, physics, and computer science.

Natural Considerations should support the student’s success in a given module either by augmenting their knowledge goals, process goals, or Thinkorithm in some way.

Natural Considerations

FAMILIAR AND ACCESSIBLE

The area chosen by the instructor should be familiar to the students. In the event that the students choose their own areas to research, the instructor must keep a close watch on the topics chosen by the students, and evaluate their reasons for researching that topic.

Examples of areas that might be good places to draw research topics might include:

TABLE 1. Potential Topic Areas for Natural Considerations

Biology	Physics
Ecology	Chemistry
Sociology	Current Events
Sports	Video Games

Furthermore, the topic chosen for the Natural Consideration should be accessible to the student. The Natural Consideration topic should not be so obscure as to be completely foreign. An element of the unknown is acceptable, but the instructor should remember that grounding the abstract in the real world is of key importance in this theory.

SELF-DIRECTED

The Natural Considerations, perhaps most importantly, may provide additional avenues for individual research and learning for the students. What motivates an individual student is a hard thing to assess, and giving them some freedom to explore other topics while working through this process can be a very important part of the student's growth as a self-actualized learner. While staying on task is important, students' passions should not be ignored, and the instructor may wish to provide some contingency plan for an individual or group of students who decide to explore a topic the instructor considers to be "secondary" or related to the module at hand.

SUPPORT A DIVERSITY OF LEARNING STYLES

Researching the Natural Consideration has been discussed here, to a greater extent, as a traditional "go-to-the-library-and-read-some-books-and-report-back-what-you-found" process. This process works well for students who assimilate textual information well, or enjoy the topic enough to explore it from this angle. However, there are many different types of learners, and likewise, many types of research.

The instructor should attempt, if possible, to capture different kinds of research in their Natural Considerations. Perhaps the notions of looping or self-similarity could be explored by listening to musics, and identifying these structures therein. The concept of preventing deadlock in multi-user computer systems (where everyone ends up waiting for one scarce computing resource), may be explored by having groups of students attempt to do accomplish one task at the same time, and then have them analyze what problems arose and how they might actually solve those problems (thus turning an abstract process into a concrete physical process).

Discussion

Group discussion has been brought up more than once as part of the Teamstorms process, and will be dealt with in more detail here. There are several ways in which discussion can enter into the classroom.

PLANNED DISCUSSION

A planned discussion is one where the students come to class prepared to discuss some question or topic. For example, students might come to class prepared to discuss some open-ended aspect of a Thinkorithm, both to talk about their solutions and discuss any other questions they might have.

Another rich area for discussion includes readings and research carried out as part of a Natural Consideration. This might take the form of questions posed by the instructor or other students, which would then be discussed after reading an article or chapter, researching some question, creature, or phenomenon in the world, or perhaps watching a video or movie. Students might be encouraged to generate their own questions in advance of the research (with direction provided by the instructor). Being able to ask effective questions about the unknown is an important part of exploring new material, and a valuable skill for the instructor to encourage in the students. The notion of “there are no stupid questions,” cliché as it might be, is sometimes hard for students to overcome.

Discussion at the beginning of class

The timing of these discussions within the class is important. By placing a discussion at the beginning of the lab allows the conversation to lead into the lab itself, and the instructor can guide discussion as necessary to lead to topics of importance to the lab. With morning labs, however, students may not yet be awake, and as such the chance of having a lively discussion of any kind is unlikely. It is also very easy for the instructor to slip into a ‘lecture’ mode first thing in the lab if students are not talkative, which is not the purpose of a discussion between the students.

Discussion when students are stuck

On challenging problems, a team of students (or several teams) might get stuck. Perhaps they have taken an approach to solving a problem that is not working, or perhaps the challenge requires some outside knowledge that they do not have. In situations like these, the instructor has an opportunity to turn frustration into a learning moment.

A discussion at times like this does many things. First, it shakes things up, allowing students to step away from the immediacy of the problem at hand. Second, it allows what was a small group process to become a large group process; this scaling of team effort does much to unify a lab section, and encourages the students to be unafraid to work with others who are not immediately on their team. In the case of particularly challenging situations, the combined brainstorming and thinking resources of the entire lab might be necessary to come up with new approaches to solving the problem at hand.

Discussion at the end of class

Discussion

By moving discussion to the end of class, the instructor opens up the opportunity for students to discuss more than just the material at hand. If the research and work they did was in preparation for the lab, they might then have the opportunity to discuss amongst each other how that research and work beforehand prepared (or didn't prepare them) for what they encountered in the actual lab. This kind of self-reflection can be orchestrated by the instructor, and may prove to be both valuable to the students and a refreshing change of pace from typical 'question-answer' discussions that many students are accustomed to.

By bringing the large group back together at the end of the period also gives the instructor a chance to close up the lab, and perhaps springboard into the next Thinkorithm and Natural Consideration. From the discussion, potential avenues for future discussion might also arise.

Discussions online

Planned discussion can also take place outside of the classroom. This might be through some sort of on-line conferencing system (First Class, SiteScape Forums, etc.), or it might be through E-mail or newsgroups.

When moving the discussion is moved online, the instructor needs to remember several things. First, their role has not changed a great deal from when they are in the classroom. Discussion still might need an experienced or knowledgeable moderator, and where appropriate, the instructor should feel free to step in and add to the discussion. This might be stagnant points in the discussion, where students have run out of things to say, or it might be heading off threads of conversation that have wandered far from the topic at hand.

Another role the instructor may find themselves in is that of a fire-fighter, putting out flames or arguments that develop due to differences of opinion. Online discussions lack tone and body language, sometimes making it difficult for users new to online forums to understand the intent of comments from their peers. Teaching students what it means to take part in an effective discussion, online or otherwise, is a non-trivial thing, and might be discussed early in the class timeline, or perhaps discussed "just-in-time," when it is needed. This might, however, be too late.

SPONTANEOUS DISCUSSION

Just-In-Time Discussion

Not all discussions need to be planned. Being flexible in the classroom is necessary when students are exploring material at their own pace, trying new things and brainstorming ideas for problem solutions. Because an instructor is being flexible according to student needs does not mean that the instructional techniques they normally use need to fundamentally change; instead, they simply much change how they use them.

Planned Spontaneity

When devising a unit, you may have some things which you feel are necessary for students to either research or discuss, some things which you feel you should talk about,

Discussion

and some which don't seem to fit anywhere, but they are valuable and important in some way.

Topics in this vague category might be saved for online discussion when topical material is wanting. Or, perhaps you expect students will hit upon it in their work, but it is tangential in some way to the main course you hope their work to take. Regardless, tangents are not always bad, and being prepared to follow students' interest, or guide discussion down an interesting path for a short period of time is a good thing.

Unplanned Spontaneity

There are, of course, those students or groups that will take you by surprise. Perhaps they found a new way to get stuck that you had never considered. Or, perhaps some group has a novel solution that you think has some excellent learning opportunities in it, whether it is a 'correct' solution or not. This might be a good time to ask that group to share their work with the class, and discuss as a class relative merits of their approach. Or, perhaps they stumbled on an important aspect of the work that you had not explicitly prepared to cover. Again, do not be afraid to use the students as a resource for other students; if you can afford the time to follow things related to the course work, don't be afraid to do so.

THINGS TO WATCH OUT FOR

Often, discussion can be used as a barometer for how well the lab or Thinkorithm was designed or written. Thinkorithms are an active background to the material that will be covered in lab - they engage the students in the thinking and problem-solving process before they actually get to the lab, as opposed to providing static background, or worse, descriptive background to the work they will do in lab. Attempting to design problems that will require students to gain some specific knowledge or implement one processes in particular is not easy; students will often find their own ways, or perhaps misunderstand the problem, thus finding their own solutions that do not apply in any direct (or perhaps even indirect way) to the problem they will face in lab.

In the event that a Thinkorithm or Natural Consideration is not well designed, and this is exhibited either by the students lack of direction in discussion (or clear demonstration of a lack of understanding in the lab process), then the discussion may need to make a drastic shift from what the instructor intended, and perhaps instead of discussing results of the Thinkorithm, instead discuss possible solutions as a large group, with the instructor playing the role of a guide or moderator to assist the students in coming to the desired conclusions. As a last resort in such situations, the instructor might resort to a Mini-Lecture, keeping in mind that the idea behind Thinkorithms and Natural Considerations is that they develop their own cognitive tools for gathering and handling processes and knowledge important to the lab or course.

When using discussion as a means for helping a group or part of the class over a hurdle or particularly challenging part of a laboratory, the instructor needs to be aware of the sensitivities of those students who are not 'getting it.' TeamStorms, if implemented well, provides numerous opportunities for students to learn from each-other, both within their team and from other teams. Success early and often (at least initially) is also important. These being values of the TeamStorms approach, the instructor does not want to let the

Mini-Lecture

success of one group belittle or diminish the confidence of other students or groups in the laboratory.

Mini-Lecture

There are times when there might not be a better way to present material to a class than to simply lecture on the subject. In the TeamStorms approach, this is the least desirable method for presenting material; discussion on previously considered or previously researched topics is always preferred. TeamStorms is striving to create constructivist learning environments in which students develop their own representations and understandings of knowledge and processes involved in solving new or difficult problems. As such, lecture should be used sparingly, and this is why it is referred to as “Mini-Lecture,” because lecture should be kept short and topical.¹

There are three primary times when an instructor might find Mini-Lecture to be appropriate; at the beginning of a laboratory, at the end, or perhaps in the middle. The latter may also be referred to as *just-in-time instruction*, as the instructor will be presenting material as it seems appropriate anywhere within the lab.

PLANNED LECTURE

Beginning lab with lecture

Beginning lab with lecture has many pluses associated with it. It provides a central starting point for the activities that are to come, giving a unified start to the lab. The instructor can easily introduce any material that they feel the student might need, be that material specific to the laboratory (safety hazards, etc.), or perhaps theory that the instructor feels that the Thinkorithm did not cover, or was not significant enough to warrant a Thinkorithm.

Beginning lab with lecture is comfortable for students, as they are accustomed to passive learning in the traditional classroom, where they come in and expect knowledge to be imparted onto them by their instructor. Early on, the instructor may find this to be useful, for giving the students some sense of familiarity with learning experiences they are accustomed to. It is not recommended, however, that students are allowed to come to rely on this as the way all labs will begin. Mixing up the laboratory, and sometimes allowing students to dive directly into the material without interference from the instructor is a good thing, and should not be ignored as a way to begin the day; staying out of the students way is, after all, a good thing.

Beginning lab with lecture also gives students the opportunity to come in late, missing lecture material and still getting their work done, while missing what the instructor felt was important enough to talk to the entire lab about. While class time is the students' time, it is also the instructor's time, and that should not be undervalued by either the instructor or the students. By mixing things up, it is possible for students to miss valu-

1. And, the author's father delivered countless 'mini-lectures' through his lifetime. They were referred to as such.

Mini-Lecture

able lab time, affecting their peers and themselves in ways that missing lecture does not. Students will generally respond to admonishment from their peers or their own sense of responsibility much more readily than anything an instructor might have to say on the issue of attendance.

Ending lab with lecture

Ending lab with lecture can be a very nice way to tie up a laboratory and introduce any material the instructor feels might be important to students as they approach their next Thinkorithm.

Unfortunately, there are many things working against an instructor at the end of a lab. Students may be well into a problem, and key on finishing or continuing to work on the issue at hand. Lab may need to be cleaned up, and students will want to maximize their work time before cleaning up and ending the lab. While these things can be organized and orchestrated so as to be done before the Mini-Lecture, students may still resent having the end of *their* work time taken from them for lecture purposes. Students may also be distracted or tired by the end of a lab period; no matter how fun or challenging a lab might be, they may also be looking forward to leaving, just to switch things up or take a break. This being the case, lecture at the end of a lab period may be the single worst time to attempt to talk about something that you hope the students will absorb and remember.

Student Led Lecture

Another approach to covering material in a lecture format might entail students being responsible for the presentation. This way, some students are still responsible for their own learning, and the rest of the class may be more attentive to the material covered, as students tend to be more receptive to their peers than the instructor with regard to classroom instruction. In this scenario, the instructor needs to be prepared to deal with any inconsistencies that may arise in the instruction, and would best meet with students before their presentation to make sure they are prepared and the information they are presenting is correct.

SPONTANEOUS LECTURE

Just-In-Time Lecture

Not all Mini-Lectures need to be scheduled. When students are particularly stuck, or lab/class slows down for one reason or another, lecture might be a more effective way for dealing with the students' problems than a discussion. In the TeamStorms approach, solving the problem or challenge for the students is never ideal - a spontaneous Mini-Lecture should **not** take this approach. Instead, it should provide hints and tips for bridging the gap between where the students are and where they would like to be.

Planned Spontaneity

There are times when you can anticipate where students will get stuck in attempting to complete a problem or challenge; especially if the instructor has left key knowledge or process goals out of the Thinkorithm or Natural Consideration. In these cases, if lecture is the planned way to deal with these difficulties, then the instructor should prepare

Play!

ahead of time, and be on the lookout for misconceptions and difficulties to key them into when they should stop class and go over the rough spots.

Unplanned Spontaneity

Truly spontaneous Mini-Lectures could be on topic, dealing with a particular problem or difficulty a group or the class is having. Or, it could be something the instructor wanted to cover that is related to the material or of interest to the students, but not directly related to the class work at hand. This might just be a 10 minute presentation on something that might interest the students, providing direction and guidance for possible student interest in topics outside of the typical classroom fare.

Play!

Play is the word TeamStorms uses for the classroom experience. Too often, class time is associated with boring, repetitive tasks, or endless lecture on topics of little interest to the students; of course, *students think it is the material they are uninterested in*. It takes a very self-aware learner to differentiate between being uninterested in the material and the way the material is presented. An instructor implementing TeamStorms should treat class time, as much as possible, as the students' time to explore the material in question. Allow time for unstructured learning and exploration. Mix up the class schedule from week to week so students do not fall too much into a routine - schedule discussion or lecture at different points in the period so as to keep students from becoming bored with the instruction itself.

Many of the larger techniques an instructor might use during class-time have been covered - Discussion and Mini-Lecture being two of them. However, dealing with the students on a one-to-one basis requires a certain amount of care and thought as well as how the entire class situation will be handled. While treating every possible situation that might arise, and providing methods for dealing with it might be nice, it is beyond the scope of this document to do so. Instead, a list of guidelines is provided, and it is up to the instructor to apply them where they see fit.

HANDLING INDIVIDUAL STUDENTS

Success Early, Success Often

While this may have to do with the lesson design more than handling students in the classroom, it is important for the instructor to do their best to build student confidence early on. Students who have achieved a series of small successes are more apt to stick with challenges when they come upon them than a student who has struggled through victory after victory. In the classroom, the instructor wants to help students early on with more prompting and suggestion to see that they are prepared not only with respect to knowledge and process skills, but also the level of confidence with which they approach problems.

There are no Stupid Questions

Play!

Students, at some point along the line, have learned to be apologetic for asking questions. This is bad; there is too much in the world that we don't understand to be afraid to ask questions. As an instructor implementing TeamStorms, it is your job to encourage questions at all times, and never belittle or condescend to a student for their apparent lack of knowledge or understanding. This does tie into the next point however, which is that an instructor should...

Answer Questions with Questions

Unless a student's question is truly beyond the scope of their knowledge or understanding (in which case, perhaps a Discussion or Mini-Lecture may be appropriate for the class in general), an instructor should refrain from giving students direct answers to their questions. If a student has a misconception about a problem-solving process, attempt to use leading questions to guide them to the solution; make them think! The instructor's goal should be for students to discover as much of their learning on their own (or through guided exploration) as possible; set an example for the class by not allowing yourself to become an easy source of solutions.

Building Respect

Students do not like to be disrespected; no one does, in fact. As an instructor, it is important to respect the students and the work they do.

Building Trust

Like respect, trust is an important thing in an instructor-student relationship. The instructor needs to be consistent in their handling of student questions and concerns, and consistent in grading, among other aspects of their classroom management. Don't let inconsistencies on your part as an instructor get in the way of student's exploration and learning.

Use Analogies

When attempting to explain something to one or more students, use analogies whenever possible. If analogies simply do not work for illustrating a concept or process, then use the actual problem at hand, and attempt through questions to guide the students to the solution as you see fit.

HANDLING TEAMS OF STUDENTS

There is a great deal written on handling teams in the classroom; what is presented here is not intended to either be complete or exhaustive. Instead, like above, it is intended to be a series of guidelines that may apply specifically to the TeamStorms approach to instruction.

Team means More than One

Students do not intuitively know how to work in groups. All too often, a strong personality can dominate a group, or a student who is more knowledgeable than others can take over much of the work of the group, thus letting less vocal or outgoing students sit by

Play!

the sidelines and watch. As an instructor, it is your job to watch for this kind of behavior, and encourage teams to make sure that everyone is able to do everything, to some degree. Having a discussion as a class early on regarding what it means to work in a team, roles that students can take (someone to keep time, someone to make sure everyone is helping, etc.), and what is important to them when working as a team is a good idea.

Encourage Intra-Team Communication

Students often think that “teams” means “competition.” This is not the case with TeamStorms, and you should not discourage teams from communicating with each-other about problems or difficulties they are having. If you foster this kind of communication early on, students will continue to learn from each-other more readily all throughout the course, thus lessening the burden on the instructor to be the only source for help and knowledge.

Working Together is not Cheating

Somewhere along the line, students learn that working together is bad; at the college level, academic dishonesty policies make it seem like even talking about the fact that there is an assignment is enough to get you expelled. As an instructor, discuss with the class how they can help each other be responsible for each-other’s learning, and what kind of help is good help, and what kind of help is just providing answers. Discussing good citation habits, even in notebooks and homeworks, can help alleviate some of these stresses as well.

Letting Go

Many instructors just can’t let go - they have to be at the front of the classroom, the fount of knowledge, the source of all questions and answers in the students’ learning experience. TeamStorms will not work if the instructor can’t “let go.” There is a time and place for instruction where the teacher is the focus, but that time is kept to a minimum in this approach to instruction.

The overriding guideline that was not presented above is that classroom time should be considered the students’ time as much as it is the instructor’s time. While the overall goals of the lesson must still be met, allow for student interest to help dictate the course. If you have a talkative group, attempt to make use of this fact, and gear more instruction towards discussion. If you have a quiet group, perhaps having more lecture-like opportunities led by students or groups of students would be a better idea. Regardless, your goal at all times is to work with students or groups of students to maximize their *learning* time, not your *instructional* time.

In Closing

What has been presented here is by no means complete. What I have tried here was to put into writing how I attempt to build a constructivist learning environment for my students. Some of this may traditionally be considered *instructional design*; however, as I am attempting to put the onus of learning more squarely on the shoulders of the student, things like Thinkorithms and Natural Considerations, while not part of in-class instruction, are key aspects of the TeamStorms approach to instruction and learning.

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