Collaboration Design Patterns: Conceptual Tools for Planning for The Wireless Classroom

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Abstract

Wireless and mobile devices are beginning to offer stunning new technical capabilities for collaborative learning. Yet, researchers in this field must recognize the importance of complementing these technical advances with improved understanding of the patterns of classroom activity that most need support. Our approach is to create conceptual tools that help us think and talk about technology-supported collaborative learning. A particularly powerful tool, we have found, is Collaborative Design Patterns, which capture common learning situations and tradeoffs in written form.

1. Introduction

Wireless and mobile devices are beginning to offer stunning new technical capabilities for collaborative learning. Yet, researchers in this field must recognize the importance of complementing these technical advances with improved understanding of the patterns of classroom activity that most need support. How can wireless and mobile technologies leverage existing practices? What kinds of powerful new learning experiences are possible? How can we guide content developers in creating a new body of collaboration-friendly content? Ultimately, our goal should be to create solutions that are both innovative and eminently adoptable by teachers.

Our approach to understanding existing classroom needs and planning for wireless and mobile devices of tomorrow has been to create conceptual tools that help us think and talk about technology-supported collaborative learning. In this paper we elaborate on one such tool: Collaborative Design Patterns.

1.1 Collaborative Design Patterns

Collaborative Design Patterns are based on Christopher Alexander's notion of design patterns in architecture [1]. Alexander invented design patterns as a literary form to capture "profound invariants" found in the highest quality spaces. Similarly, we adopted design patterns to describe best practices in collaborative learning. More than just descriptive, our Collaboration Design Patterns offer us a shorthand to effectively communicate collaborative activities, and provide building blocks for more complex situations.

Our selection of Collaboration Design Patterns focuses on those that could be enabled or enhanced with wireless and mobile technology. We adapted the design pattern form used in Buschmann, et al. [2] as shown below.

- *Name:* The name and a short summary of the pattern
- *Problem:* The problem the pattern addresses, including a discussion of its associated forces
- *Example:* A real-world example demonstrating the existence of the problem and the need for the pattern
- *Context:* The situations in which the pattern may apply
- *Solution:* A resolution of the problem stated in terms that could be applied in many situations
- *Implementation:* The fundamental solution principle underlying the pattern
- *Technological Assumptions*: What infrastructure must be in place for the implementation to be practical
- *Variants:* A brief description of variants or specializations of a pattern
- *Consequences:* The benefits the pattern provides, and any potential liabilities
- *See Also:* References to patterns that solve similar problems.

To clarify how a researcher of wireless and mobile devices can use Collaboration Design Patterns we highlight applications we have encountered while collaborating with Texas Instruments (TI) Educational and Productivity Solutions. TI has used patterns to illustrate to teachers how solitary calculator activities can be made collaborative. We have used patterns to check the generality of a proposed collaboration network infrastructure. The Technological Assumptions category of our patterns (our own extension to the standard form) helped us articulate the requirements of a desirable collaboration system to TI engineers.

We have identified three main types of collaboration patterns:

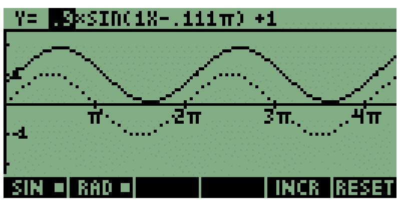
1. *Whole Activity Patterns:* describe how collaboration takes place over the course of an entire activity
2. *Data Patterns:* describe how artifacts are exchanged during a collaborative activity

Proceedings of the IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE'02)
0-7695-1706-4/02 $17.00 © 2002 IEEE

3. *Support Patterns:* describe smaller-grained patterns that enable forms of collaboration to take place.

The rest of this paper is divided into four collaborative scenarios, based on real classroom activities, which we mine for collaboration design patterns. In the Moon Phase scenario we describe the whole activity pattern *Touching the Elephant* and the support patterns *Exchange Template* and *Contribution Layering*. We mine the Revolutionary War scenario for the whole activity pattern *Crystal Ball* and the support pattern *Presentation Template*. In the Salmon Watch scenario we introduce the whole activity patterns *Pipeline Workflow* and *Jigsaw*. Finally, the Bias Circles scenario provides context for the whole activity pattern *Coopetition.*

2. Moon Phase Patterns



We use the following mathematics scenario, based on a real classroom activity[1], to introduce the next three patterns: A teacher uses an activity exploring the phases of the moon to introduce students to argumentation about mathematical modeling and matching data to a model. She gives each team three unique points of moon phase data from one month, with each phase point represented by a fraction of a full moon. Student teams then experiment with different values that they enter into a pre-loaded sinusoidal function on a graphing calculator.

The model function is of the form

$$0.5 * \sin(f * (t - B)) + 0.5$$

Where f represents the frequency of full moons, and B, phase-offset—roughly speaking, the phase of the moon on the initial day of the data set. Students are not told the meanings of these variables explicitly. Rather, they are expected to discover these connections in the process of the activity.

Students are to identify function parameters that results in a graph that comes closest to fitting their given points. They must reflect on the different strategies that can be used to find functions with the smallest error. The ultimate goal is for students to explore the role that frequency and offset play in relation to the moon data.

Day One. After working through this process for half the class period, each team "publishes" two bits of information in an electronic form created by the teacher that includes:

- "Best fit" frequency and offset predictions
- Check boxes for the strategies used to identify "best fit" frequency (e.g., trial and error, induction from knowledge of the 30-day moon cycle, etc.)
- Check boxes for their predictions about how to represent the relationship between best-fit frequency and phase-offset in a mathematical formula. That is, if you fix a phase-offset and adjust the frequency for a best fit, then change the phase-offset and find the new best-fit frequency, what is the relationship between the phase-offset change and the frequency change?

These "published bits" of information are transmitted to all other teams for review and discussion. Teams can then decide whether to change their ideas or defend them.

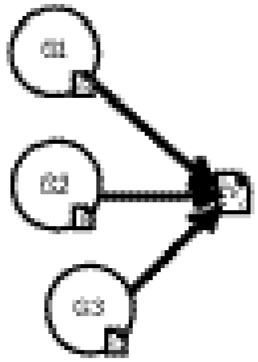
Day Two. Student teams finalize their presentation of their arguments. Whole class discussion follows with each team reporting their predictions. The teacher then aggregates each team's data and shows how all 10 sets of three data points flow together into one sine wave for a full month of moon activity, with each set of three data points color-coded and labeled by team. The teacher needs the ability to call out each team's data sets one at a time, highlighting them individually, and then be able to "layer in" each succeeding team's data points. She also needs the ability to plug in different frequency and phase-offset numbers to change the overall sine wave dynamically in order to lead discussions comparing different predictions.

2.1 Touching the Elephant

The Moon Phase scenario highlights a common whole activity pattern called Touching the Elephant. This pattern has already been documented in the Pedagogical Patterns Project[2]. Here we expand on how it can be applied particularly in collaborative settings.

[1] See <http://www.comap.com/highschool/projects/mmow/assets/Macintosh/Course3/Unit5/Resources/U5TEACH.PDF> and <http://mach.usno.navy.mil/cgi-bin/aa_moonill.pl>

[2] See <http://www-lifia.info.unlp.edu.ar/ppp/>



Problem. Grasping the vastness of a new topic is difficult, particularly for students weaned on worksheet pedagogy. Students who work with a sample of data that is too small can draw erroneous conclusions. It is important for students to gain “intellectual humility” by gradual exposure to the larger problem.

Example. In an effort to create a “teachable moment,” the teacher in the Moon Phase scenario wants each group to start by working on a small part of the curve-fitting problem. That is, she wants students to start out by conceptualizing the problem as simpler, or at least different, than it actually is when taken as a whole. However, she then needs a way to pull back from the particulars and reveal “the big picture.”

Context. Small groups exploring a complex phenomenon.

Solution. Students are given some early experience in examining a small part of a larger phenomenon, with the intent of showing them the complexity of the field they are about to study.

Implementation. The teacher prepares the activity by dividing the phenomenon being studied into parts that can be worked on independently. The teacher then initiates the activity by introducing the problem to the whole class, forming students into groups, explaining to the class that each group will receive only part of the problem, and distributing the prepared parts to at least one of the handhelds in each group. After groups have had sufficient time to work on their part of the problem, the teacher finishes the activity by collecting the partial solutions from each group onto a local server, displaying a visualization of the combined solutions on a shared display, and conducting a class discussion of how the parts make up the whole (see Contribution Layering below.)

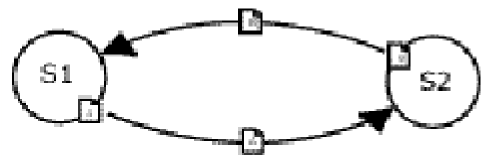
Technological Assumptions. The implementation assumes:

- A means of associating handhelds with a group
- A means of tagging student artifacts by a group ID so they can be distinguished on the local server
- The availability of appropriate visualizations tools for the subject matter being explored.

See Also. Touching the Elephant can be combined in interesting ways with Coopetition, a whole activity pattern described later.

2.2 Exchange Template

The scenario underscores the frequent need for information transfer, which we have captured as the Exchange Template support pattern.



Problem. In many collaborative activities students need to exchange their work with peers. If peers use different types of conventions for reporting their work, valuable class time may be lost while students interpret the artifacts they received from their peers.

Example. The teacher in the scenario needs all teams to quickly exchange the frequency and phase-offset values that best fit their data. If this were the complete content of the exchange, this could be done trivially by transmitting single values back and forth, or even shouting out numbers. But, the teacher also wants students to compare the strategies they used and their predictions. The challenge is to allow this qualitative information to be exchanged too, in a way that affords quick comparison.

Context. Between-student comparison of qualitative results.

Solution. Standardize reporting conventions by constraining results to a template or form on a student’s handheld device. Possible template items include multiple choice and fill-in-the-blank questions. When the templates are exchanged, students can more quickly notice differences.

Implementation. In preparation, the teacher authors a form with multiple choice and fill-in-the-blank options. When students begin the collaborative activity, the teacher distributes the forms to each student’s handheld, or—in the event the class has been divided into groups—perhaps only the handheld of the group “recorder.” At a teacher-defined checkpoint, the teacher asks students to exchange their work by sending their forms over a peer-to-peer network (alternatively, students could send their work to a server responsible for redistributing the forms to peers.) After receiving others’ forms, each student or group compares the received form to their own. This could be accomplished on one handheld with a split screen or a view-toggling UI. Alternately, multiple handhelds could be used within a single group: one for displaying the group's own work, and the other for the outside solution.

Technological Assumptions. The implementation assumes an authoring tool for creating Exchange Templates, and a "player" application on the handheld that can interpret the forms and constrain student responses appropriately.

Consequences. While Exchange Template may make collaborative activities more efficient, there is often pedagogical value in students having to confront the unfamiliar representations of their peers. These confrontations can result in interesting meaning-negotiations between students.

2.3 Contribution Layering

The scenario highlights the value of visualization, which we encapsulate here as the Contribution Layering support pattern.

Problem. Teachers may want to show how student groups are transforming data individually, but also how each group's results are contributing to a larger pattern

Example. At the end of the scenario, the teacher wants to display an aggregation of all student work, while preserving the identity of the group associated with particular data.

Context. Students working with subject matter that lends itself well to graphical visualization. Requires a display visible to the whole class.

Solution. Graphically represent contributions from each group as a layer in an overall visualization. Allow layers to be selectively made visible or hidden for discussion purposes. Layer attributes such as color can automatically be linked to the source of the contribution to help clarify who did what.

Implementation. After an exercise, each student or group contributes their work via the nearest hub to the local server. The local server stores each contribution in a file location unique to the contributor or tags the file with the contributor's ID. The server also runs a visualization tool that maps data in the contribution files to the classroom display. (Data from each contributor is an independently controllable layer in the visualization. Settings in the tool determine how contributor and other logical attributes of the data map to visual attributes—e.g. color—in the display.) The teacher then conducts a class discussion by adjusting the visibility of layers, selectively highlighting regions of the screen with annotation tools similar to those found in presentation application such as Microsoft PowerPoint.

Technological Assumptions. The implementation assumes

- A means of tagging student artifacts by a group ID, so they can be distinguished on the local server
- The availability of a visualizations tool for the subject matter being explored that recognizes the group IDs
- A UI in the visualization tool for changing layer visibility and highlighting.

Variants. Students could be at the controls of the visualization tool for classroom presentation purposes. They could use the visibility adjustments and highlighting to show their work and compare it to their peers.

See Also. Contribution Layering is useful for supporting the discussion phases of the Touching the Elephant activity pattern.

3. Revolutionary War Patterns

The next scenario, which we use to introduce two new patterns, is based on a social studies activity used by TI to expose teachers to collaborative learning concepts: A teacher wants students to think critically about why historic events unfolded the way they did. In this scenario, students act as military historians to determine why the underdog Americans beat the powerful British in the Revolutionary War. To support students in making a complex, textured argument, they are organized into groups and work collaboratively in two stages. First the students learn about how military historians analyze the strength of different armies. Then separate student groups review different battles at different points during the American Revolution to find evidence of changing relative capabilities between the two sides.

Day One. Students first separate into groups and read articles analyzing the relative military strength of different armies in other famous historical battles at different times in history so they can familiarize themselves with how military historians analyze relative capabilities of armies. Using their handhelds, students study the texts and generate electronic lists of criteria that historians use to compare and contrast the different armies. Criteria could include size of army, leadership, technology, strategy, and political support. The teacher concurrently displays the category lists and leads students in a discussion to pare down the list to the essential criteria. These criteria become the fields in a template form used in the next day's activity.

Day Two. Different student groups review different collections of historical accounts of different individual battles between the Americans and the British at different points in the course of the Revolutionary War. As each group reads about their specific battle, they enter evidence about the relative strengths and weaknesses of each army into the template developed on the first day, which lists evaluative criteria. For each criterion, students rate the two sides of the battle using a numeric scale.

After reading their set of accounts, each group tallies the scores per army under all the criteria and then generates, automatically, a prediction number about which side will most likely win the war. First, these tallied figures are displayed for the whole class, and then a discussion follows, revealing which battles were being analyzed and how expectations about who would win shifted from the beginning to the end of the war.

Day Three. On the final day of the activity, each group in the class presents its evidence in more detail, focusing on the evaluative criteria that played the biggest role in shifting the expectations of which side would win the war. During discussion, students are asked to present detailed charts showing the different scores for specific criteria assigned to the two respective armies and why.

At the end of the class, all evidence and criteria are aggregated across groups and made available to students on a class Web site or printout. Students' homework is to use the evidence generated by their group and all the other groups to explain how changes in relative strength of the different armies played a role in the ultimate outcome of the Revolutionary War.

3.1 Crystal Ball

The Revolutionary War scenario describes the common student task of making predictions, which we have captured as the whole activity pattern Crystal Ball.

Problem. Students need to be able to think critically about the past and argue using evidence about the future. This involves gaining experience with using history to make predictions, but recognizing that such predictions are often dependent on how one interprets evidence.

Example. The teacher in the Revolutionary War scenario wants students to analyze battles from the American Revolution using criteria employed by historians. Then students are to use their analysis to make predictions about the outcome of the Revolutionary War. At the end students will confront differing predictions and reflect on the evidence that matters most.

Context. Chronological subject areas such as history, but could also include the physics of motion and probability.

Solution. Student teams review distinct evidence about a case or a series of cases. They use that evidence to make a prediction about future outcomes.

Implementation. The teacher initiates the activity by introducing the case(s) to be studied, working with students (perhaps in groups) to identify important kinds of evidence, and dividing students into groups to examine different cases. Each group then uses the agreed-upon evidence categories to characterize their assigned case and makes predictions about future outcome(s). After groups have had sufficient time to work on their case, the teacher finishes the activity by asking each group to present its case. The teacher aggregates the evidence from each group into a single document. As a follow-up activity, students can reflect on this aggregate data and form an opinion regarding the key factors that predict future outcomes.

Technological Assumptions. The implementation assumes:

- A means of sifting through evidence categories as a class or a small group (e.g. white board or shared electronic display)
- Group formation techniques, allowing either the teacher to pick groups or individuals to self-select
- a means of recording a group's characterization of a case and predictions
- Convenient connections between the device(s) used by a group and a shared display for whole-class presentation purposes
- The teacher can easily capture student data from various devices for aggregation purposes
- Each student can quickly obtain whole-class results so they can reflect on this information, possibly from home.

See Also. The Exchange Template support pattern provides a pattern for collecting the analysis data that need to move across the class network. Presentation Template (below) is useful for supporting the recording of student findings in preparation for whole-class discussion.

3.2 Presentation Template

A familiar subtask illustrated in the above scenario is class presentations, which we address here with the Presentation Template support pattern.

Problem. Class presentations, while important, can be intimidating and can take time away from learning a topic in the first place. It can be difficult for students to compare across presentations if some are disorganized or simply structured differently.

Example. The students in the Revolutionary War scenario need to be able to present a cogent case to the class. However, the analysis task is enough of a challenge, without asking students to devise a good presentation sequence and choose appropriate data displays (graphs, charts, tables, etc.) for their information, particularly when students are to draw conclusions from multiple presentations. A technique is needed that ensures a consistent presentation format, allowing across-group comparison.

Context. Students engaged in detailed analysis, leading to whole-class presentations

Solution. Students record data into a template that is already organized for class presentation. Information displays such as graphs are automatically computed. A presentation mode for the template provides tools for advancing through sections of the analysis.

Implementation. Students conduct their analysis with a template prepared in advance. At a minimum the template must provide an entry mode, in which students can enter analysis data. The template may also have a presentation mode, intended for displaying in front of the class. Otherwise, students present what appears in their entry mode as is.

Data entry involves typing values into fields, or using widgets such as checks boxes, radio buttons, and sliders. As students enter data, presentation-relevant information displays such as statistics, graphs, charts, are generated automatically. Templates supporting a presentation mode provide PowerPoint-like widgets for navigating sections of the analysis, and perhaps the ability to annotate pages in real-time, based on comments from fellow students.

Technological Assumptions. The implementation assumes

- A document type that is an editable form
- A means of specifying form field constraints
- A means of constraining user input according to the above specification
- Convenient connections between the device(s) used by a group and a shared display for whole-class presentation purposes.

4. Salmon Watch Patterns

We use the following science scenario, adapted from the Oregon-based Salmon Watch program[3], to introduce the next three patterns: A middle school teacher wants to engage her students in a science project focused on taking measurements of water quality in riparian habitats. Their visit to a river requires several phases of data collection and some remote data sharing to improve on-the-spot calculations.

Morning Phases. In the qualitative data collection phase of the river visit, the students interview a Native American storyteller about the river's history and hike with a naturalist who describes how to differentiate native plants in disturbed and undisturbed states. Student groups select technological tools to support data collection for their encounter with the storyteller. One group decides to use a text input tool for the interview, where each group member takes notes. Others decide to use a voice-recording device. Those using the text tool aggregate their text in "separate but equal" fashion, having each group member take notes using a text input tool and making their input visible to all other members after they submit it to the wireless network.

Back in the classroom at a later time, groups use these collected notes as a source of information for each group's report about the history and changing water quality of the river they are studying. Group using the voice recording tool listen to the speech and collaboratively write their report back in the classroom.

Afternoon Phases. In the quantitative data collection phase, students observe plant life in different locations, noting whether it is disturbed or undisturbed; visit a salmon spawning site and estimate the number of active salmon living there; tour a hydroelectric dam and estimate the rate of water flowing through it; and count aquatic invertebrates in a nearby stream bed.

For the native plant life analysis task, the group divides up to cover the whole area, each member recording and simultaneously sharing observations in real time. Using a decision tree tool, group members identify and tally various species. The tool is an interactive taxonomy that walks students through the evaluation of a plant's structure that botanists use to classify the plant as disturbed or undisturbed.

For the stream flow estimation task, students organize workflow sequentially. Each group member works on a shared document in a prescribed order to facilitate water flow calculations.

For the aquatic invertebrate survey, students also use an aquatic invertebrate tally form to record the numbers of each type of species taken at different sample locations. Students can again divide the responsibility and then aggregate their sample records in one database. Back in the classroom, the various databases become sources for students to describe their methodology and evidence in their final report.

4.1 Pipeline Workflow

[3] See <http://www.ortrout.org/edu/salpro.htm> and <http://www.4j.lane.edu/partners/eweb/ttr/>

The relaying of results illustrated in the Salmon Watch scenario fits a common whole activity pattern we call Pipeline Workflow.

Problem. A teacher needs to organize student activities in a complex task in a way that allows each student to play a meaningful role that requires cooperation with other students.

Example. The teacher in the Salmon Watch scenario wants students to participate in the process of measuring rate of water flow from the dam in an efficient but inclusive way. She needs an activity that allows students to collect their parts of the data and then share those findings in a sequential way with other members of the group so they can complete the calculation.

Context. Small groups executing a complex data collection task.

Solution. Students work individually on a shared and accumulating data form. As each student completes his/her portion of the data calculations, he/she sends the revised form along to the next student in the sequence.

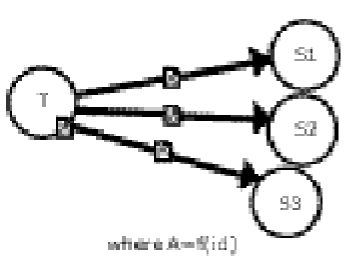
Implementation. The teacher initiates the activity by describing data collection procedure and rationale, forming students into group, and distributing a base blank form to the first group member assigned to the first task in each group. Next, the teacher instructs students on how to operate within the sequence and how to save and send the form along, including to the final database.

Technological Assumptions. The implementation assumes:

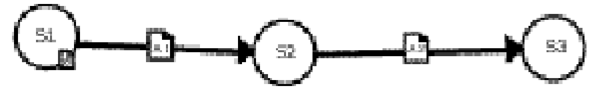
- A means of associating handhelds with a group
- A means of allowing sequenced saving, sending and updating of documents within a group
- An authoring system so the teacher can create forms.

4.2 Jigsaw

The scenario underscores the frequent need for students to play complementary roles, which we have captured as the whole activity pattern called Jigsaw. This pattern name comes from the jigsaw method for cooperative learning pioneered by Aronson et al. [3].



Problem. A teacher needs to organize student activities (A) in a complex task (T) so that students have equal



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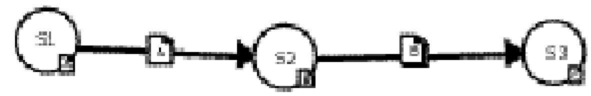


status, share common goal, and each have something to contribute that is not dependent on his or her peers.

Example. The teacher in the Salmon Watch scenario wants students to collect data about native plant conditions and collect counts of aquatic invertebrates. She needs an activity that has students conducting the same work but separately on each team.

Context. Small groups executing a complex data collection task.

Solution. Students work individually on similar or different data forms that are aggregated in some fashion.

Implementation. The teacher first takes a large topic and divides it into 5-6 segments. She then selects heterogeneous groups of students, forming "home" teams. Each student learns one segment (or creates or discovers something related to it, etc.) without consulting his or her peers. Next, the student leaves the home team to confer with students from other home teams working on the same segment. They help refine each other's knowledge. Students then return to their home teams and present their segments. As an extension, the home team can perform a task that draws on the learnings from the presentations.

Technological Assumptions. The implementation assumes:

- A system for associating individual members in each group with specific responsibilities and form types
- An authoring system for forms.

4.3 File Structure

The scenario highlights the need to manage intermediate artifacts during an activity, which we encapsulate here as the File Structure support pattern.

Problem. In complex collaborative activities with multiple steps, students and teachers need a way of accessing multiple forms and documents that may change during the course of the activity.

Example. The teacher needs ways for students to obtain one of several forms during the course of the salmon watch activity: text input files for Native American storyteller task, plant species disturbance checklists for the analysis task, and calculation forms for the water flow rate task. Each of these sets of forms needs to be associated with specific groups.

Context. Several small groups executing complex data collection tasks.

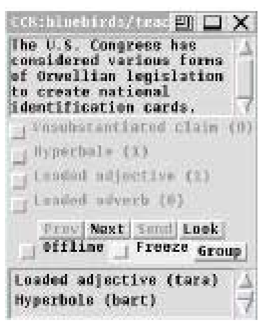
Solution. A file structure for the handheld device that enables students and the teacher to keep different datasets associated with different groups distinct, and that enables members of each classroom group to access their specific forms when necessary in an easy way.

Implementation. The teacher initiates the activity by showing students how to navigate the file structure, forming students into groups and assigning each group a node within the file structure.

Technological Assumptions. The implementation assumes:

- A means of associating handhelds with a group
- A means of distributing the same sets of forms to different groups' files
- A means of accessing this file system.

5. Bias Circle Patterns



This last scenario, which we use to introduce one more pattern, is based on the "literature circles" [4] employed by language arts teachers to encourage critical reading: A high school English teacher wants to expose his students to different forms of bias in journalistic writing. Students divide into groups around different articles from newspapers or magazines. They first individually review the chosen text for different types of bias, and then each group compares and contrasts their individual observations. Later, the teacher conducts a whole class discussion where students reflect on the bias they noticed or failed to notice.

Identifying Bias Categories. To begin, the teacher initiates a class discussion about bias by asking students for examples of bias they have encountered in everyday life and conversation as well as in journalistic writing and reporting. What kinds of words and phrases indicate bias? The teacher then guides the class in selecting four categories of bias to be used in the reviews. He notes the final selections on his handheld, which configures the reviewing software on each of the students' devices.

Group Formation. Next, students browse a collection of recent newspapers and magazines for articles of interest. Students group themselves around a few topics of interest and then each group agrees on an article to review. Once selected, they download the article to each of their individual devices.

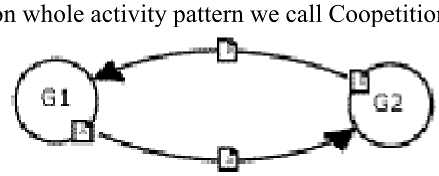
Reviewing. At this point individuals in each group have a copy of their group's article and reviewing software preconfigured for the bias categories identified earlier. The software lets students examine the article one sentence at a time and tag any sentence with any combination of the four bias categories. To check alignment with fellow group members, students can temporarily enable a "look" feature, which shows the bias tags that others have marked for the same sentence.

Comparing and Contrasting. When all students in a group have finished reviewing their articles, the teacher asks individuals to compare their observations. The discussion is aided by the reviewing software, which can now be used to compare everyone's tags for all sentences. The goal is not consensus, but the conversation may persuade a student to change his or her choice of tags.

Discussing. The activity ends with the teacher leading a discussion on the visibility of bias. He asks students to reflect on the bias they noticed, failed to notice, or could not agree on. The groups will likely have different kinds of reflections based on the nature of their articles, and their own personal experiences and histories.

5.1 Coopetition

The Bias Circle scenario illustrates the purposeful duplication of work leading to enlightening comparisons, a common whole activity pattern we call Coopetition.



Problem. A student needs exposure to the idea that a problem can have many solutions, and that solutions do not always compete with one another, but can complement each other, and/or the differences may inspire further thinking.

Example. The teacher in the Bias Circles scenario wants students to see that bias can appear in literature in many forms and that the degree of bias is a matter of interpretation. He needs an activity that allows students to look individually for bias, and then to compare and contrast their different perspectives. A subgoal is that students learn to defend or correct their own inferential procedures.

Context. Small groups exploring a complex phenomenon.

Solution. Groups of students work in parallel on a problem. At scheduled check points, intermediate solutions are exchanged between groups and discussed.

Implementation. The teacher initiates the activity by introducing the problem to the whole class, forming students into groups, and distributing identical or related data or worksheets to at least one of the devices in each group. The teacher also informs groups of the first checkpoint (perhaps indicated by a countdown timer on an interactive worksheet.) At each checkpoint, the teacher asks students to exchange their intermediate solutions with one or more other groups (this can be implemented in a variety of ways, including peer-to-peer connections directly between handhelds in different groups, or using a client-server model where each group sends their data to a server responsible for redistribution to the rest of the groups.). At the end of a check point the teacher asks students to compare and contrast their work with that from other groups (see Exchange Template for ways to support this.)

Technological Assumptions. The implementation assumes:

- A means of associating handhelds with a group
- A means of tagging student artifacts by a group ID for exchange purposes
- The ability for a handheld to maintain and switch between at least two sets of data: one from the owner of the handheld and the other from a peer.

Variants. There is no reason why Coopetition participants cannot be individual students instead of groups. In this case each student might work in parallel and then later join a class discussion where results are compared. Indeed, the Bias Circles scenario actually layers both the group and individual forms of Coopetition. There is Coopetition between individuals reading the same article, and between the groups reading different articles.

See Also. Coopetition can be combined in interesting ways with Touching the Elephant.

6. Conclusions

We hope our selections convey a sense of the communicative power of Collaborative Design Patterns. Our own experience with these patterns is that they quickly become a conceptual tool that can elevate design conversations to a higher level. A pattern offers a real-world example that can guide technical discussions (sometimes giving birth to a software structure by the same name.) At the same time Collaboration Design Patterns provide non-technical templates for generating high-quality collaborative learning activities that make the most of emerging technologies. Only by advancing both the technology and the content in this way can we expect wireless and mobile technologies to succeed in education.

7. Acknowledgements

This research was sponsored by Texas Instruments, Inc. under SRI project #11649. Special thanks to Corey Brady, Sarah Davis, Matthew Diaz, Gretchen Perkins, Diana Byrne, GT Springer and Kelly Woods from TI for their contributions.

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