



## College Quarterly

Spring 2007 - Volume 10 Number 2

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### A Metacognitive Pedagogy: The River Summer project

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#### Abstract

This article describes River Summer, an interdisciplinary, field project on the Hudson River. Using cognitive data, the team aimed to design an experience that fostered an environment implementing strategies that improve learning. The participants, 40 faculty members from 24 institutions who acted as teachers, students, or both, boarded the Seawolf, the vessel on which the course was situated. River's objectives included lessons for analyzing various aspects of and promoting awareness for the Hudson and its watershed as a natural and cultural environment. Most importantly, this paper illustrates River's incorporation of metacognitive strategies as an effective teaching and learning tool.

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#### A metacognitive pedagogy: The River Summer project

In the summer of 2005, Barnard College and Pace University, on behalf of the Environmental Consortium of Hudson Valley Colleges and Universities, launched River Summer—an interdisciplinary, integrative, field-learning project on the Hudson River. Diverse faculty worked together to provide an effective pedagogical setting in which “students” could learn about the Hudson River and its surrounding areas stretching from the New York City harbor to the heart of the Adirondacks. In groups of 8-10, a total of 40 faculty members from 24 institutions moved onto the Seawolf, an 80-foot research vessel operated by SUNY Stony Brook and the project's home base, to embark on a month-long, 5-module “class” on the Hudson River. Some members acted as teachers, others as students, and many had switching roles, depending on the module and the topic. During the course of River Summer, the faculty discovered new facts about the estuary, discussed and debated issues concerning art, politics, environment, ecosystems, development, and other related topics, and formed intellectual collaborations that have continued after the project ended. Major questions on the minds of faculty were how to implement learning and teaching strategies that would benefit long-term learning, what procedures would get others to think about their thinking, and which sessions would most effectively transform a passive student into an active one. A fundamental goal of River Summer was to serve as a testing ground for a “metacognitive pedagogy.”

This article describes the steps leading to the design of a metacognitive pedagogy centered on issues related to the

development of the Hudson watershed. In the first section, the notion of metacognition—or an awareness of learning—is described briefly. Then, two cognitive strategies that have been shown to be effective for long-term learning in the laboratory are introduced. Finally, this paper illustrates River Summer's incorporation of metacognitive and cognitive strategies as an effective teaching and learning tool.

### **Metacognition**

From a theoretical point of view, metacognition has been defined in a variety of ways, but all descriptions have shared a common theme— that of an awareness of one's own thinking, learning, or knowledge states. For example, metacognition has been described as knowing about knowing or privileged access, and many have used the term almost synonymously with consciousness, self-reflection, and self-awareness (Flavell, 2000; Hart, 1965; Janowsky, Shimamura, & Squire, 1989; Metcalfe & Shimamura, 1994; Shimamura & Squire, 1986; Tulving, 1994; Tulving & Madigan, 1970). From an educational point of view, metacognition has been defined as the ability to monitor ongoing learning and then to control subsequent study strategies (Brown, 1987; Flavell, 1976, 1979; Kluwe, 1982; Nelson & Narens, 1990, 1994). Here, metacognition will be a concept encompassing all of these definitions and is described as an awareness of one's own learning and, thereafter, the process of taking active control of one's learning strategies.

Research on the topic of metacognition has grown a great deal over the past several decades. Most recently, investigation of people's individual strategies during study has been the central focus (e.g. Dunlosky, Kubat-Silman, & Hertzog, 2003; Kornell & Metcalfe, in press; Son, 2004, 2005). Questions have included those that ask how a learner chooses to allocate time to study, how one chooses to schedule study, and how a learner decides to test him or herself. Educators have also recognized the value of instruction that focuses on the development of strategies for thinking and independent learning (Baker & Brown, 1984; Flavell, 1979; Hartman & Sternberg, 1993; Palincsar & Brown, 1984, 1989; Stahl, Simpson, & Hayes, 1992; Sternberg, 1986). Using a metacognitive approach to teaching— encouraging students to identify learning goals and to choose the most appropriate strategies for reaching those goals—has improved people's ability to understand, retain, and transfer knowledge to new situations.

Merely being metacognitive—being active and aware—is not enough, however, to ensure improvements in long-term learning. In addition, the learner (or teacher) would need to choose the right cognitive strategies—those that have been found to be effective in boosting learning. What types of strategies would be the right ones to incorporate into one's study practices? In the next section, two strategies investigated extensively in the cognitive field are introduced.

### **Cognitive strategies**

The past few years have witnessed the collection of substantial amounts of data on cognitive strategies that are successful in enhancing performance over the long term. Here, the focus is on two of the strategies that psychologists have found to be consistently beneficial. They are the spacing effect and the generation effect. The mechanisms proposed as the reasons for their advantages include active retrieval, context variability, and encoding specificity, which are also addressed.

Spacing is a strategy in which one studies information across a significant period of time, taking relatively long breaks between numerous study sessions. This is in contrast to massing, where study is crammed into one uninterrupted session. Even when the total study time is equal in the two cases, cognitive researchers have repeatedly found that if the goal were to enhance test performance, individuals should space rather than mass their study—a phenomenon known as the spacing effect (Dempster, 1987; Hintzman, 1974; Mammarella, Russo, & Avons, 2002; Melton, 1970; Toppino, Hara, & Hackman, 2002; Underwood, 1970; see Son, 2004 for a review).

In a typical laboratory experiment examining the effects of spacing, participants are presented with a list of items. Within the list, each item is shown twice. Some of the items are massed—shown in immediate succession—while other items are spaced—separated by other items. For example, in the following list excerpt “[...] shoe, bear, bear, moon, shoe [...]” the item “bear” is massed, whereas the item “shoe” is spaced. Later, when tested on all of the items for free recall, participants are better at remembering “shoe” than they are at remembering “bear.” The spacing effect has also been found with less laboratory-like materials such as texts (Dempster, 1988b), lectures (Glover & Corkill, 1987), and vocabulary (Baird, Baird, Baird, & Baird, 1993; Baird & Phelps, 1987; Dempster, 1987).

One reason as to why spacing might help long-term learning is that it (more so than massing) allows for a high degree of context variability (Birnbaum & Eichner, 1971). During spaced study sessions, the task environment is likely to be more variable and more unpredictable on each study occasion. Furthermore, having experienced study in those contexts would prepare the learner better for the final test, which is, itself, bound to be more variable and unpredictable. The notion that learners perform better when the study and test environments are similar—a phenomenon known as encoding specificity—has been well documented in the field of cognitive psychology (Roediger, 2000; Spence, Wong, Rusan, & Rastegar, 2006; Thompson & Tulving, 1970). Another convincing explanation for the spacing effect has been the retrieval hypothesis (Glover, 1989), which suggests that people take part in a more active retrieval process in spaced study (because some forgetting has occurred since the last study sessions) than in massed study (where the materials have not yet been forgotten). As a result of the active processing, strengthened or newly created “retrieval routes” to the correct representation of the target in memory are formed (Birnbaum & Eichner, 1971; Bjork, 1975;

Donovan & Radosevich, 1999; Ebbinghaus, 1885; Glenberg, 1976, 1977, 1979; Glenberg & Smith, 1981; Melton, 1970).

The second effective strategy of interest is that of the generation effect. The generation effect has been defined as the increase in learning after actively testing oneself (generating the information) over passively reading the information. Discovered by Slamecka and Graf (1978), the effect is extremely robust and has been shown to occur with a variety of learning materials, including words (Jacoby, 1978; Mulligan, 2001), sentences (Graf, 1980), bigrams or 2-letter sequences (Gardiner & Hampton, 1985), numbers (Gardiner & Rowley, 1984), and pictures (Kinjo & Snodgrass, 2000; Peynircioglu, 1989).

In a typical laboratory procedure investigating the gains from generation, participants are presented with a list of cue-target pairs (e.g. chin-game). Then, the pairs are separated into two different conditions: Generate and Read. In the Generate condition, the cue is presented with only a fragment of the target (e.g. chin-g\_\_\_\_) and participants are asked to try to retrieve the target. In the Read condition, the entire cue-target pair is presented (so only passive reading is required). Then the participants are given a subsequent cued-recall test where only the cue is presented. Results have shown that pairs in the Generate condition are remembered significantly better than those in the Read condition. As in the spacing effect, some have proposed that the mechanism of the generation effect is the high degree of cognitive activity required in retrieving the correct response (Begg, Snider, Foley, & Goddard, 1989; Crutcher & Healy, 1989; Gardiner, Smith, Richardson, Burrows, & Williams, 1985; Griffith, 1976; Hirschman & Bjork, 1988; Tyler, Hertel, McCallum, & Ellis, 1979). In addition to cognitive effort (and again as in the spacing effect), one can also imagine that encoding specificity—the finding that the Generate condition creates an environment more like that at final test—would give rise to the generation effect.

The existing laboratory data regarding both of the above effects suggest that learners and teachers alike may employ spacing and generation strategies in the classroom as a way to build a metacognitive classroom—such that these strategies would encourage active retrieval, broaden both context variability and encoding specificity, and as a result improve long-term learning. Although a few studies have demonstrated cognitive benefits using school materials (e.g. Dempster, 1988a; deWinstanley, 1995; Glover & Corkill, 1987) and several have encouraged the wider use of such strategies in the educational system (see especially Bloom, Englehart, Furst, Hill, & Krathwohl, 1956, and more recently, Anderson & Krathwohl, 2001), metacognitive strategies are not normally used in classrooms today (see Dempster, 1992). One major problem is that the two fields—cognitive psychology and education—do not normally come into contact with each other. Thus, the effectiveness of cognitive strategies remains largely unknown to students and educators in the school system. Even when educators know that certain strategies enhance learning, a deep understanding of the mechanisms is lacking. This

may lessen the perceived value of the strategies and in turn discourage the usage of such methods. Finally, although some educators know of their effectiveness, they often have trouble putting cognitive strategies into practice in the classroom because they are not sure how to implement them (Dempster, 1988a, 1992; Dempster & Farris, 1990; Vash, 1989). The following quote illustrates a once extreme view of the lack of applied strategies: "Education policy setters know perfectly well that [spaced practice] works better [than massed practice]. They don't care. It isn't tidy. It doesn't let teachers teach a unit and dust off their hands quickly with a nice sense of 'Well, that's done'" (Vash, 1989, p. 1547). It is easy, on the other hand, to envision a classroom as a lecture space (without any variation in location) with one (same) teacher in charge at the front of the room while all of the students face the teacher, passive. Consider, for example, a general college course like biology, art history, or economics. There are probably few spaced study sessions (as there is too much new information to get through in one semester) and very little generation (one or two midterms could easily be the maximum obligatory retrieval sessions in one course). Students themselves will often become passive listeners in the class and will be found cramming immediately before the exams—these strategies unfortunately being the two non-optimal counterparts to generation and spacing.

The cultivating of metacognitive pedagogies in existing classrooms, particularly at the college level, has been meager. And some propose that the problem is the classroom itself (Cuthbertson, Dymont, Curthoys, Potter, & O'Connell, 2003). They write, "Most learning in these institutions tends to happen inside large, but often cramped and windowless, rooms." (p. 78). The same authors subsequently offer a new proposal: "What if nature was conceptualized as teacher instead of merely a backdrop for activity, or if entire courses occurred outside? And what if the theoretical groundings of these experiences were intentional and designed to be pedagogically coherent with course goals and objectives?" (pp. 78-79). In the next section, we outline briefly some of the ways in which cognitive and metacognitive strategies may be enhanced when learning in the field, and finally, we illustrate how the River Summer Project provided such a "field classroom" environment.

### **Learning in the field**

Given that context variability may be the mechanism driving the benefits of cognitive strategies such as spacing and generation, the field—the ultimate variable context—may be the most optimal location for learning. Priest and Gass (1997) identify the following as being associated with field learning: direct and purposeful experience, appropriate level of challenge, natural consequences, participant-based change, present and future relevance, and perhaps the three most important in terms of metacognitive strategies, synthesis and reflection, participant responsibility for learning, and active engagement. Powers (2004) presented survey data that evaluated how field-based learning changed teacher's classroom practices and

found that the “use of community provides teachers and students with diverse viewpoints, access to resources, facilities, and financial support, as well as a broader base of skills and knowledge.” (p. 21) In addition, she outlined 6 points of impact on teacher methods. They are: (1) use of local places and resources, (2) interdisciplinary teaching, (3) collaboration with other teachers, (4) teacher leadership and personal growth, (5) stronger curriculum planning skills, and (6) greater use of service-learning in the curriculum—all of which enhance both cognitive and metacognitive thinking. And in Dittrick’s theoretical framework (adapted from Powers’ 2004 model), “if one develops an attachment to one’s place and has the skills to proceed”, that individual will become a “more active participant in the community” (p. 20). And finally, depicted in the framework is the idea that with field learning comes an increase in self-awareness, self-confidence, and maturity, as well as a broadening and deepening of individual participation and community engagement.

Researchers have also incorporated field-based learning into their own teaching regimens. For example, Cuthbertson’s (2003) group, who have designed four different courses taught almost entirely in the wilderness of the Canadian outdoors, describe field learning as “nature as classroom” where students can take what they have learned in the classroom (or from a textbook) to the field and “grapple with the ramifications of their actions.” (p. 87) They also discuss the benefits of keeping a journal, where students keep a log of their experiences, allowing for an “integration of skills and theory” (p. 89) and for reflections of “connections between the classroom experience and outdoor activities. (p. 90) Similarly in the cognitive field, in addition to increasing the number of spaced study sessions, summarizing has been shown to enhance text comprehension (e.g. Block & Pressley, 2001).

Newbery and Henderson (2003) also write about using the field experience and a “change of place” to “romance students.” (p. 152). And one of the things that they highlight is that learning should not necessarily be a comfortable, repetitive endeavor. For instance, in their own class, “students move in for a nose-length and novel view of the imposing cement structure that houses their classrooms and gymnasias. The cassette player...lyrically chants this lament for a culture that has lost its forest floor...” And the teacher remarks “You weren’t expecting this class to be normal, were you?” (p. 153) Such methods that foster variability and unpredictability are exactly in line with the advantages gained from spacing and generation strategies found in the cognitive field.

“Many... will remember field trips that were important parts of their primary and secondary education—the field trips to look at bugs, trees, rivers, clouds, or historical sites, and then draw or write about them. But somewhere in the leap to university-level education this sun-on-the-face, wind-in-the-hair, cold-feet-and-dirty-hands approach to learning vanished.” (Crimmel, 2003, p.10) A major goal of the River Summer Project on the Hudson was to design a learning space at the

secondary level—a “classroom”—that would bring back the cold-feet-and-dirty-hands technique, allowing for more direct strategies rooted in metacognitive and cognitive research. In order to do so, three tactics were utilized: (1) Researchers and educators worked together to build the project, (2) a preliminary workshop about cognitive research findings (including those of the spacing effect and generation effect) was held prior to organizing the project, and (3) participants combined the knowledge gained in the fields of cognition and metacognition and implemented, as much as possible, the above-discussed strategies that enhance long-term learning as well as the awareness of them. Finally, most notably, the River Summer classroom transpired in the field.

### **The River Summer Project**

#### **Project objectives**

In sync with the previously stated goals, River Summer was a field-course on the Hudson River with the following objectives: (1) to promote effective cognitive and metacognitive learning and teaching strategies, (2) to be interdisciplinary and multi-institutional, (3) to design lessons for studying, debating, and analyzing various aspects of the Hudson watershed, and (4) to promote awareness and appreciation for the Hudson and its watershed as a natural resource and cultural environment. The course was designed to integrate the field-based experience with cognitive research showing that people learn best when they take active control of their own learning. It provided both content and pedagogy that participants could later integrate into their own teaching and scholarship at their home institutions. To maximize diversity and variability and to create a larger community of knowledge, the curriculum was deliberately focused at the convergence of different fields: natural sciences, social sciences, law, history, and the arts.

#### **Location**

The course was divided into five modules connected to five locations on the Hudson River. They were: Upper Hudson, Mid Hudson, Lower Hudson, New York Harbor, and the Adirondacks. For all modules except for the Adirondacks (which was held in various locations in the Adirondack area), a large part of the River Summer course was held on the Seawolf, a research vessel owned by SUNY Stony Brook. There were also numerous lessons at various docking sites of the Hudson River and in surrounding watershed areas.

#### **Design Team**

The design team for River Summer was made up of researchers, policy makers, scientists, and educators. The co-chairs of the project were Stephanie Pfirman (Chair of Barnard College’s Environmental Science Department and a leader in environmental curriculum development) and John Cronin (Pace University’s Resident Scholar in Environmental Studies and Director of the Pace Academy for the

Environment Program). The project director and coordinator was Tim Kenna (Associate Research Scientist and Geochemist at Lamont-Doherty Earth Observatory and Adjunct Assistant Professor at Barnard College). Also contributing to the design of the project were Michelle Land (Director of the Environmental Consortium of Hudson Valley Colleges and Universities, Program Coordinator of the Pace Academy for the Environment, and Adjunct Professor at Pace University's Environmental Studies program) and Lisa Son (Assistant Professor of Barnard College's Psychology Department) who served as the project's learning consultant.

### **Participants**

River Summer participants—teachers, students, or both—were comprised of researchers and professors in the fields of art history, biology, botany, computer science, chemistry, ecology, economics, education, English, environmental science, geochemistry, history, law, and political science. There were 40 participants (20 males and 20 females) coming from a total of 24 different institutions. The breakdown of the participants' fields of expertise was 60% natural sciences/engineering and 40% social sciences/humanities.

### **Curriculum**

Through River Summer, the Hudson Valley became an extended classroom and laboratory for faculty to investigate the development of the watershed within an interdisciplinary framework. The curriculum included lessons on fisheries, river habitats, plant diversity, ecology, geology, and geochemistry. The landscapes, art history, and development of the Hudson River watershed were also examined. There were frequent writing workshops and lessons in local archaeology and anthropology. Waterfront revitalization and pollutant remediation were also discussed in sessions on local political economy and environmental law.

### **Preliminary Workshop**

A month before the project began, the River Summer team met at the Seawolf, docked at Pier 63 in lower Manhattan, for a one-day introductory session with as many of the participants as possible. The participants met each other and were introduced to the captain and crew of the Seawolf. A presentation and discussion regarding the objectives of River Summer was held in the first session of the workshop. The two chairs presented information about the goals of the project as well as the Hudson River. The director then introduced the logistics of the course, the lesson topics, and the scheduling of the five different modules. The learning consultant gave a summary of some of the research from the cognitive field presenting data regarding effective and ineffective long-term learning strategies, including theories of the spacing and generation effect and the mechanisms of active retrieval, context variability, and encoding specificity. A discussion about differences between classroom and field learning

ensued. Differences between passive learning and metacognitive learning were also addressed.

At the end of the workshop, participants boarded the Seawolf, familiarizing themselves with the various rooms and bunks that would be 'home' during River Summer. They also learned some facts about the Hudson River – its history, location, and the processes by which river data are obtained, including a preliminary lesson on sea floor coring techniques and sediment collection. Thus, the participants had an opportunity to meet one another and begin to acclimate themselves to their summer "classroom," and their field-based, metacognitive course.

### Module Design

The course was divided into five modules: Upper Hudson, Mid-Hudson, Lower Hudson, New York Harbor, and the Adirondacks. The first four modules were four days long; the last module was a week, and each followed a standard procedure. Each module began with a "local hero" lecture in the evening. The local hero lectures were designed as informal introductory sessions that gave participants the opportunity to get to know each other and hear about one (expert) individual's Hudson-related career journey. Over subsequent days, lessons on the River took place in the morning, afternoon, and early evening. See Table 1 for a list of topics that were covered in each module.

At the end of each day, participants filled out questionnaires about the daily lessons, pedagogical styles, and knowledge gained (see Appendix A for a sample questionnaire given to participant teachers). Questions included: How would you rate the series of lessons? How would you rate the topics? How would you rate the teaching strategies? All were rated on a scale from 1 to 5 (1 = poor and 5 = excellent). Some open-ended questions were also asked: e.g. What was the most memorable teaching experience/strategy of the day, and why? For each module, participants also filled out pre- and post-questionnaires about the River Summer teaching and learning experiences on the whole. Questions included items (rated always to never) such as: I encouraged discussion between students; I acted as a guide for students, not someone who is in charge; I allowed students to debate their opposing views and feelings. They also included open-ended questions such as: What are some of the River Summer strategies that you would like to incorporate into your classroom teaching practices, and why? At the end of the module, the group came together for a final wrap-up session during which they focused on the pedagogical styles of the course, the interdisciplinary themes that were covered (or that might have been lacking), and what might be improved for future programs.

### Project outcome

To assess the success of the project as a field-based

“classroom,” the daily questionnaires, pre- and post-questionnaires, and wrap-up sessions were reviewed. First, a subset of the open-ended comments about the River Summer experience on the whole was examined. The answers that the participants gave, regardless of whether one was a teacher or a student and of one’s field of expertise, were very similar across the board. Most of the responses were extremely positive, and many remarked about the success of the interdisciplinarity of the program, variety in curriculum, engaging discussions, and new collaborations resulting from the experience (see Table 2 for some detailed comments on River Summer as a whole).

Numeric ratings for each of the modules were also averaged across participants. Three aspects of the module were rated (5 = excellent, 1 = poor) by each participant: (i) general lessons, (ii) topics, and (iii) teaching strategies. The mean scores across all days of River Summer were 4.44, 4.48, and 4.43 respectively. The first three columns of Figure 1 show the means for each module. As is shown, all modules were rated very highly, and some modules (e.g. 1, 3, and 5) were rated as higher on all three aspects than other modules.

To measure how “metacognitive” the River Summer course was, the number of strategies—particularly those that would foster active learning, not passive learning—was recorded. Throughout the entire 5-module course, numerous types of pedagogical techniques were used. For simplicity, those techniques were broken down into six different categories from the most passive (from the learner’s point of view) to the most active. The categories, displayed in Figure 2, could be summarized as follows: (1) lecture, powerpoint, verbal presentation; (2) small group, team collaboration, discussion, debate; (3) observation and demonstration; (4) sampling, fieldwork, labwork; (5) writing, drawing, photographing; and (6) discovery and problem solving.

Building on the knowledge of cognitive strategies such as the spacing and generation effects, a crucial approach to increase long-term learning would be to use those strategies that foster active, not passive, retrieval. Here, strategies that are considered active are those other than straight lecture or small group discussion: those that fall within categories 3 – 6. For example, having students demonstrate how to build a filtration system (category 3), or paint the same landscape that the Hudson River School had painted (category 5), or catch and identify fish using a seine and a keying book (categories 4 and 6) would all be especially active strategies that would result in superior long-term learning. The number of active strategies used in each module is presented in the fifth column of Figure 1. As can be seen, between one and two active strategies were applied to the program for each module. The percentage of non-active strategies, like straight lecture, powerpoint, or verbal presentations was also calculated for each day—the means are displayed in the last column of Figure 1. Those modules that were rated more favorably than others also had the highest proportion of active strategies.

Another tactic for boosting learning, perhaps a simpler one, would be to increase context variability, either through a more variable number of teaching strategies or a larger number of different learning environments. In a typical classroom, students receive one or at most two strategies or contexts—usually a lecture in a lecture room and a discussion in a laboratory or small group space. The mean number of strategies that was used each day at River Summer (taken from the daily questionnaires) was 2.85 (see the fourth column of Figure 1 for the module breakdown)—already an advantage over a regular classroom. Moreover, the diversity in environmental settings was easily superior. The lessons took place in a variety of locations; the kitchen and deck of the *Seawolf*, smaller boats, marshes surrounding the river, beaches of the river, piers, walking tours, museum visits, college laboratories, and tents just to name a few.

A significant benefit of the River Summer classroom for faculty was their increased awareness of their teaching strategies; the participants evaluated their strategies based on what others had tried before, modified them “on the fly” during the program, reflected on their teaching and/or learning experience and many are now applying them in their classrooms at their home institutions. In Figure 3, the responses people gave to the questions regarding their teaching experiences at the conclusion of their module are shown. These responses suggest that a “metacognitive classroom” would not seem too difficult to achieve. For example, more field work, group collaborations, reviews and ungraded quizzes are just a few of the responses that people gave. Each of these policies would help to increase the number of learning instances using generation strategies, spacing strategies, and their beneficial mechanisms.

### Conclusion

The River Summer project was a success on all accounts. Researchers and educators worked together and were able to learn about and try to implement effective strategies based on research from the cognitive and metacognitive fields. The participants formed a truly interdisciplinary and multi-institutional group. For many, their awareness of and appreciation for the Hudson and its watershed was deeper than expected. Below was the overall response of the project’s learning consultant who was a student throughout all five modules: “River Summer was an experience like no other. From a student’s perspective, I can say that I learned a significant amount of information, not only about the Hudson River and its surroundings, but also about the larger issues that researchers tackle pertaining to waters and the environment in general. I also believe that learning was easier because of the diverse cognitive strategies and varying outlooks on the information provided during the lessons. In a nutshell, I have learned that the environment is a collaborative, cross-disciplinary problem, one that can only be solved when environmentalists, researchers, and thinkers from a variety of angles and fields can come together to debate, teach, and learn actively.”

Metacognition—awareness of knowledge—is a growing research field that has slowly extended into the realm of education where it most belongs. Data have shown that metacognitive strategies boost learning at the individual level, and in this paper, the River Summer project has provided evidence for the possibility and advantage of a metacognitive classroom. Implementing teaching and learning techniques that use more active processes, such as those promoted during fieldwork, creation, and discovery, can result in an educational experience that is exciting, challenging, and rewarding all at the same time.

This is not to say that the so-called passive strategies (such as verbal lectures) are of no benefit in the classroom. On the contrary, many of the lessons throughout River Summer began with a brief lecture or introduction distributing basic concepts, vocabulary, and discussion questions about which to think. Certainly the learner must begin with fundamental information before branching out into more active debates and spontaneous discoveries. What seems most ideal for a classroom, however, would be a union of the two types of pedagogical methods—to keep the fundamental lectures and introductions while adding the active components of study, rehearsal, spacing, and generating directly into the classroom experience. This ideal was realized during River Summer 2005.

**Table 1.** The list of topics covered in each module.

Module 1: Upper Hudson	Hudson River School painters, Environmental compliance and enforcement; riverscope instrumentation for near-real time data collection, writing the Hudson, fisheries biology, the new political economy of the Hudson River Valley; and CTD sampling.
Module 2: Mid-Hudson	Geology of the Hudson River Valley; writing the Hudson, brownfield case study; origins of environmental law; human settlements as ecosystems; littoral zone ecology; and CTD sampling.
Module 3: Lower Hudson	CTD sampling, estuarine circulation and sediment coring; the political economy of the Yonkers Waterfront; sustainable land use and dispute resolution; Piermont Marsh-Wetland Brackish Hudson ecology and paleoecology; writing the Hudson, Denning's Point historic and pre-historic site visitation; and the New York City water supply.
Module 4: New York Harbor	Acoustic surveys and sediment coring in New York Harbor, the Clean Water Act, panoramas and see fever: Visualizing the Hudson; wastewater treatment; and CTD Sampling.

Module 5: The Adirondacks	Adirondack geography and ecosystems, a 2-day wilderness camping experience, GPS and orienteering exercise, writing from place; tree identification exercise; mapping/forest/ ecosystem exercise; tour of the Tahawas and McIntyre mining areas; economy and ecology in the Adirondacks; land ownership and property rights; Blue Mountain Lake Adirondack Museum visit, and arts, culture, and nature in the Adirondacks.
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**Table 2.** Direct quotes from the questionnaires pertaining to River Summer as a whole.

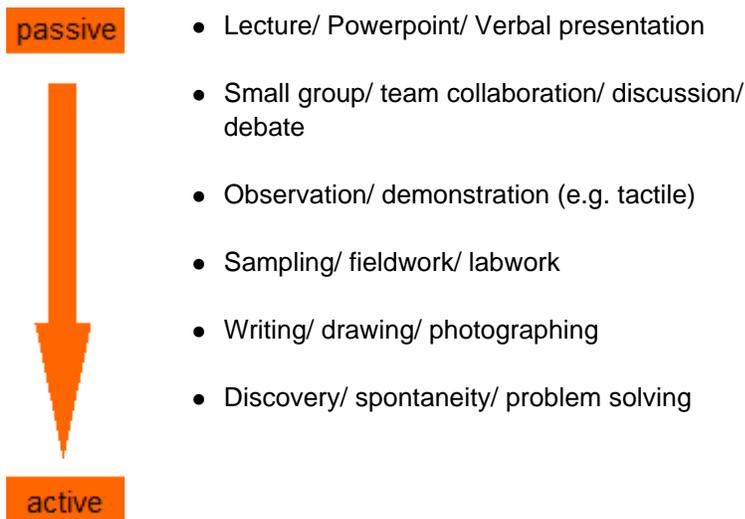
Module 1: Upper Hudson	Topics were excellent. Sessions were excellent. Hands-on sessions were extremely effective and memorable. Personal topics (i.e. writing) were great, making the bonding much stronger. Diversity of the teaching styles was worthwhile. Excellent interdisciplinary methods.
Module 2: Mid-Hudson	Co-teaching very effective - boosts integration. The passion of the instruction was wonderful. Assignments were good.
Module 3: Lower Hudson	Discussions were great, different points of view raised, and each addressed, "informalness" was effective Yonkers lecture, walk: we can see the development happening "right before our eyes" Team work and competition for filter-making was fun and motivating. Using role reversal (having students teach faculty) was extremely effective. Overall, an excellent, unique module.
Module 4: New York Harbor	Sonar/Coring: fascinating, interdisciplinary themes can be highlighted It was good seeing a "law" perspective of the river Panorama: great collaboration. Extremely helpful to walk through the treatment plant.
	Camping session: excellent package, fantastic, amazing, great bonding

Module 5: The Adirondacks	<p>experience</p> <p>Economics lecture: powerpoint effective because of the discussion</p> <p>Great museum tour</p> <p>Limekiln/George: sampling great, good repetition from earlier modules.</p> <p>Great to have outside researchers participate and teach for diverse points of view.</p>
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### Figures

Module	Overall rating	Topics rating	Strategies rating	Number of strategies	Number of active strategies	% Passive lessons
1	4.61	4.65	4.68	3.30	1.78	29.7
2	4.25	4.35	4.34	2.70	1.25	31.5
3	4.70	4.60	4.60	2.35	1.45	28.9
4	4.00	4.29	3.93	2.64	1.29	33.1
5	4.60	4.20	4.40	4.00	2.00	25.0
<i>Mean</i>	<i>4.44</i>	<i>4.48</i>	<i>4.43</i>	<i>2.86</i>	<i>1.50</i>	<i>31.3</i>

**Figure 1.** Questionnaire data for modules 1-5. Columns 1, 2, and 3 are the mean ratings of the module as a whole, the topics, and the teaching strategies respectively. Columns 4 and 5 represent the mean number of total strategies and active strategies used respectively. Column 6 displays the mean percentage of lecture/verbal strategies used on each module.



**Figure 2.** Categorical descriptions of teaching strategies, starting with the most active and ending with the most passive.

<b>"What were some of the best aspects of learning on River Summer?"</b>	<b>"What did you learn about you learning/teaching strategies?"</b>	<b>What are some of the River Summer strategies that you would like to incorporate into your classroom teaching practices, and why?</b>
Getting a big picture of the Hudson	Learning better when I am "doing" rather than "hearing"	Fieldwork with students where they do a project individually that ties to a group project
The variety of teaching styles	To incorporate less lecture and have more hands-on experiences	Bringing students to field sites with well thought out activities
The investigative approach	I liked having the info (lecture) with the hands-on activity as much as possible	Problem solving in real settings
Large amounts of hands-on activities	I learned not to be afraid of new tasks	Local hero idea – a great way to engage students
Fieldwork	Writing really helped me crystallize my thoughts	Multiple discipline classes
Teamwork	Data fascinate me there are no data in my field	More collaborative work
Being on a research ship	Challenges for students are motivators (competitions)	Ungraded quizzes/reviews I've never done that and it makes sense to help students remember and also to help them see what might be asked on exams
Being outdoors	I need quiet time to process information	More writing assignments
Team teaching	At first, I had just planned to do a lecture ...After the first day, I changed my plans to start with a question, asking the students to question	Incorporating more "data" into writing

	throughout. I think that the reverse strategy worked well.	
Meeting other faculty and interdisciplinary		Assignments that require students to synthesize information in new ways

**Figure 3.** Compiled questionnaire data. Participant responses to questions pertaining to the River Summer experience, the assessment of teaching strategies, and the transferability of effective strategies to a typical classroom setting.

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