Design and Use of Instructional Materials for Student-Centered Learning: A Case in Learning Ecological Concepts

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Efforts to improve students' learning outcomes have suggested the need to embed the use of educational technology in a learner-centered learning environment where students construct their own meanings. In this study, video documentaries that asked students to explore problems associated with farmers' use of ecologically unsound agricultural techniques were developed and used in a student-centered class. Their learning outcomes and experiences were compared to a group of students who studied the same topics in a teacher-centered learning environment. Results showed that the improvement of the student-centered group's understanding of the problems was consistently higher than the teacher-centered group. Data on learning experiences also showed that the learner-centered learning environment tended to engage students in knowledge construction, while the teacher-centered environment, information absorption. Overall findings suggest that technology can change and improve the quality of learning outcomes if designed to support knowledge construction in a learner-centered learning environment.

Keywords: Role of technology, Effective learning, Learning outcomes, Constructivist learning

Changes in society and workplace have exerted pressure on the educational system. For instance, with increased internationalization, growing knowledge-intensive work, and increasing use of information technology, schools are required to produce graduates who do not only possess relevant knowledge but also interpersonal relations and communication skills, ability to work in various contexts, and information literacy skills (Sakamoto, 1996; Allen, 1996; Burgess, 2000).

In response to this challenge, schools are now moving towards a more learner-centered approach to learning. The reason for this is that the teacher-centered approach characterized by transmission of information is sadly insufficient to equip students with the above skills. In fact, many studies show that the teacher-centered approach only promotes misconceptions and inert knowledge (Schank, Berman, & Macpherson, 1999; Bruer, 1994), a form of knowledge that can be recalled when prompted but cannot be applied in practical situations (Cognition and Technology Group at Vanderbilt [CTGV], 1992). On the other hand, the learner-centered approach, building on students' current knowledge and abilities (Lambert & McCombs, 1998), enhances the development of higher-order skills such as critical thinking and problem-solving. This method enables students to acquire knowledge that transfers to novel situations (e.g., CTGV, 1996; Bransford, Brown, & Cocking, 2000; Bransford, Franks, Vye, & Sherwood, 1989).

To facilitate student-centered learning, many authors suggest the use of media and technology (Wang & Woo, 2007). However, in this type of learning, technologies should shift their role from being conveyors of information to a means for engaging students in thinking. More specifically, technologies should be used to pose problems to students, provide related cases and information resources, a social medium to support learning through collaboration and interaction, and intellectual partners to support learning by reflecting (Jonassen, Peck, & Wilson, 1999). In this way, technologies would no longer become "full" systems (Zucchermaglio, 1994) that do nothing but transmit information to the learners, tools that can lead students to experience the knowledge construction process (Edelson, Pea, & Gomez, 1996).

Existing literature is replete with information on how to design technologies that can support knowledge building. All these consistently disregard methodologies that lead to pre-specification of content to be learned, decontextualization of information, and criterion-referenced evaluation of student performance, processes that form the heart of such models as instructional systems design model (Kemp, 1977), learning systems design model (Gagne & Briggs, 1979; Ely & Gerlach, 1981), and media utilization model — ASSURE (analyze, set objectives, select media and methods, use, revise and evaluate [Heinich, Molenda, Russel, & Smaldino, 1996]). More specifically, the alternative design process does not follow such procedures as gap analysis, analysis of learner's existing capabilities, designing strategy for effective communication of information, and testing to determine how students remember the ideas transmitted. Instead, it proceeds by choosing tasks that are relevant to the learner's lived experience.

Current moves to integrate sustainable agriculture concepts into the agriculture science programs have provided the opportunity to apply the alternative approach to designing educational technology. In this paper, we describe the results of a study that involved the implementation of a learning unit using documentary video materials. We report the process that we adopted in designing the learning unit and developing the instructional materials and compare students' learning outcomes and experiences with a group who studied the same concepts in a teacher-centered classroom.

METHODS

Research setting and participants

This study involved the implementation of a learning unit on ecologically unsound agricultural practices in a three-hour laboratory class on a fundamental course on ecology, a required program of study for all college students in the university where this study was conducted. As an introductory course, the class aims to introduce students to fundamental concepts in ecology, ecosystems processes, and effects of human activities on the environment. The setting of the study was a state university in the Philippines offering both graduate and undergraduate education in agriculture, forestry, veterinary medicine, and allied fields.

Designing the learning unit

The learning unit was designed in line with efforts to integrate sustainable agriculture concepts into the agriculture science curricular programs. Currently, various sectors including the academe, government, and non-government organizations are pushing for such a curricular reform as the content of the said programs are no longer relevant to the needs of the time. Reports (e.g., Conway & Pretty, 1991; Conway & Barbier, 1990), for instance, show that the use of advanced scientific methods (e.g., dependence on agrochemicals) taught to students as methods to improve food production are resulting in environmental problems that threaten not only the food supply but also the existence of human beings. The goal, therefore, of the integration is to provide students with a balanced perspective of development and environment.

Design of the learning unit began with discussions with the teacher regarding the coverage and objectives of the course. From these discussions, it was decided that the unit be on such agricultural practices as cultivation of hilly areas without the use of erosion control measures, excessive use of inorganic fertilizer, and heavy pesticides spraying.

Designing and developing the video materials

Although the ideal method would have been to take the students to the farms where these farming techniques are applied, this idea was ruled out in favor of the use video for two reasons:

1. Through consultations with staff of environment-oriented projects, it was learned that the farms were in far-flung communities. Thus, on the part of the students, a field trip would mean expenses and missing some of their classes.
2. As an educational medium, video has intrinsic potentials of presenting realistic information (Heinich et al., 1996). Informal interviews with some school staff showed that the school has video facilities accessible for instructional purposes.

Following the suggestion of the environment-oriented projects staff, the videos were taken in two farming communities. One community was into vegetable production, and the other, cutflower production. The video on vegetable production was entitled "Health and Wealth from Veggies," while the one on cutflower production, "Flowers in the Hills". In an effort to bring authentic problem situations to the classroom, the videos were produced as documentaries.

To ensure technical accuracy of the video materials, the scripts were subjected to a review by subject matter specialists prior to production. To ascertain comprehensibility of the presentation, the videos were shown to a group of students who matched the characteristics of the intended users. Their comments showed that the videos were generally understandable and acceptable.

The distinguishing feature of the video materials was in the manner by which the information was learned by the students. In contrast to traditional materials that provide content, the videos posed challenges to the students. The objective was to engage them in active knowledge construction, unlike when they watch television where they are mere passive information receivers. The use of the videos, therefore, required changes in the structure of the class activities. Foremost of these was to embed them in problem-exploration activities, instead of using them as "add-ons" in lecture-dominated classes. The teacher's role also shifted from being a source of information to being a facilitator.

Implementation of the learning unit

The learning unit was implemented for three weeks (one meeting was for three hours). Thus, every week's class was devoted to exploring an ecological problem; that is, students studied sedimentation, eutrophication, and development of pest resistance during the first, second, and third weeks, respectively.

Each class began with a short orientation of the day's activities and playing of the video. Working in small groups, students conducted discussions to answers the challenge (e.g., "In this situation, how can cultivation of hilly areas contribute to soil erosion and sedimentation? What techniques should farmers use to minimize these problems?")

As a reference, a guide containing the video summaries and descriptions of the problems was developed. Related cases (e.g., examples that can provide students with experiences that can be mapped into the new task [Jonassen et al.,1999]) were provided by the teacher through leading the students in identifying the effects of various environmental problems that struck the country. For instance, on the topic on cultivation of hilly areas, the teacher led the students in identifying the problems that led to the tragic 1991 flash floods in a city near the university.

As the students were discussing their answers, the teacher kept on monitoring students' progress and provided scaffolds by asking them about their answers (e.g., "Why do you think anaerobic condition would lead to death of fishes?"). Likewise, after coming up with their answers, some groups, determined by drawing lots, were asked to report their outputs. Class interaction ensued with the instructor as moderator. In this interaction, other members of the class challenged the groups' position. The group, on the other hand, tried to defend their opinion. At the end of the presentations, the instructor summarized the discussions, correcting students' misconceptions that emerged from the interaction.

Evaluation of Learning Outcomes and Experiences

Learning outcomes and experiences of students in the learner-centered (LC) environment was compared with those in a teacher-centered (TC) environment. The LC was composed of 37 students with ages ranging from 17-29 ($M = 19.65$; $SD = 2.06$), while the TC had 20 students whose ages ranged from 17-24 years old ($M = 19.15$; $SD = 2.16$). The videos in the LC presented cases of ecologically unsound agricultural practices. At the end of each video, students were posed with a problem to solve.

On the other hand, in the teacher-centered learning, students learned using the traditional methods. Lessons in the TC and LC were similar. The second author taught both classes and evaluated students' answers. His fields of specialization are watershed management and agroforestry.

At the beginning of the study, a pre-test was given to all classes. A week after the last topic, a similar test was given. Based on the current thrust of higher education – that is, to equip students with skills in communication and decision-making (e.g., Allen, 1995) — and consistent with the aim of learner-centered learning to engender deep understanding (Lambert & McCombs, 1995), the tasks required the students to explain and reason. More specifically, the question was: "In your own opinion, how could cultivation of hilly areas (excessive application of inorganic fertilizer or heavy pesticide spraying) cause sedimentation (eutrophication or development of pest resistance)? What steps should the farmers take to address these problems?" The highest possible score was 100% — that is, 50% each for discussion of the problems and recommendations. For the discussion part, the bases were completeness and accuracy of the arguments, while for the recommendations, the criteria were completeness and accuracy of the discussion, appropriateness, and workability of the recommendations. To determine differences of the group's understanding of the ecological problems, the *t*-test was used. In the analysis, only students with complete data – those with data in the pre- and post-tests — were included.

The phenomenographic analysis (Marton & Booth, 1996) was used to determine the qualitative conceptual changes of students' understanding of ecological problems. The answers were then read to determine the distinct ways in which students described their views about how a practice causes the problem indicated. In the analysis, the analytic unit was not the individual answers. Instead, the answers were handled as a whole to find out what Marton terms as "the pool of meanings." Aside from the differences, attention was also paid to similarities; when expressions differed at the word level but carried similar meaning, these answers were placed into the same category. The categories resulting from the analysis covered the whole variation of different ways in which students described their views of the problems. Establishing descriptive categories is the main result of the phenomenographic analysis. Pre-and post-tests

Table 1.
Brief discussion of the environmental sedimentation, eutrophication, and development of pest resistance (based on Nebel & Wright, 1996).

Sedimentation
Sedimentation is the deposition of soil particles or sediments in low-lying areas and such bodies of water as rivers, lakes, and seas. Eroding sediments are carried into these bodies of water, where they clog channels and cause flooding, fill reservoirs, kill fish, and generally destroy the ecosystem of these waterbodies. As a problem, sedimentation has been identified as a major cause of the destruction of coral reefs worldwide and the depletion of the groundwater resources. The reason is that, instead of refilling the water reservoir, rainfall just runs off.

Eutrophication
The problem on eutrophication involves nutrient enrichment in such waterbodies as rivers and lakes. The problem starts with washing of nutrients into these waterbodies that subsequently allows the rapid growth and multiplication of phytoplankton. In this condition, the water becomes turbid. This then prevents the penetration of sunlight to the benthic plants. Photosynthesis of these plants is then hampered, thus creating an anaerobic condition due to the depletion of dissolved oxygen. This results in the death of higher level organisms like fishes and shells.

Development of Pest Resistance
Pests develop resistance due to heavy pesticide spraying. A genetically based phenomenon, this resistance builds up because when pesticides are applied, the more sensitive individuals in a pest population are killed. But the individuals that are genetically predisposed to be resistant to pesticides survive. Repeated applications of chemicals then quickly eliminate all susceptible insects in the population. But resistant individuals are retained. In a short period of time, the entire population of insects become resistant. Complicating the problem is that, with farmers' frequent pesticide spraying, the number of resistant species increases. And as a pest population becomes resistant to one pesticide, it also gains resistance to other, unrelated pesticides, even if the species has not been exposed to these chemicals.

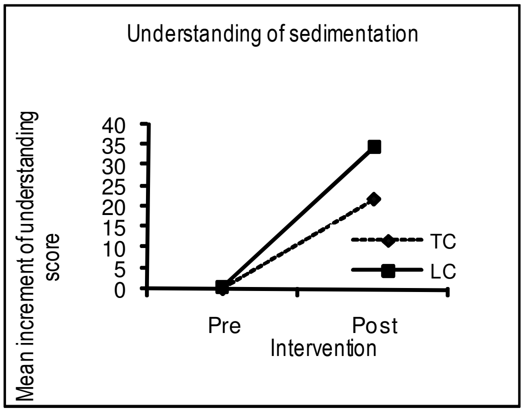
conceptions were compared vis-à-vis the scientific conceptions (see Table 1).

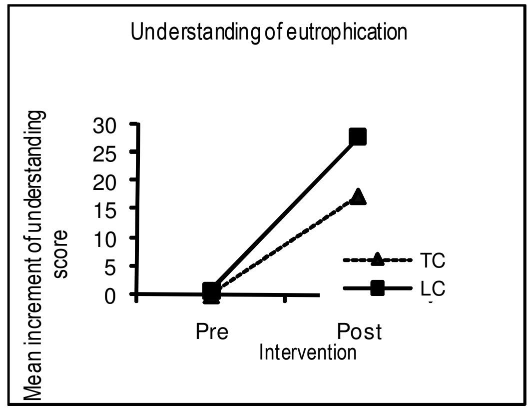
Data on learning experiences were gathered through discussions with some students from each group. Students participated in the discussions either as volunteers or as per the teacher's request. The discussions were recorded on audiocassette tapes and were content analyzed.

RESULTS

Understanding of the ecological problems

Figure 1 shows the differences of the increment of students' understanding scores in the ecological problems they have studied. In sedimentation, for instance, the learner-centered (LC) group (*M* =





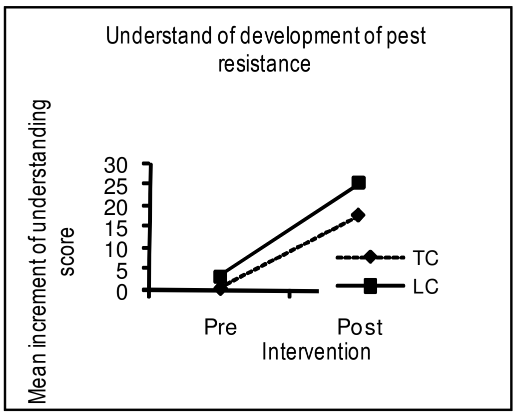


Figure 1.
Mean increment of understanding scores of the teacher-centered (TC) and learner-centered (LC) groups in sedimentation, eutrophication, and development of pest resistance.

33.83, *SD* = 12.24) scored highly significantly higher than the teacher-centered (TC) group (*M* = 21.89, *SD* = 9.79), $t(53) = 3.76$, $p<.001$). Likewise, in eutrophication, incremental score of the students in LC (*M* = 26.97, *SD* = 14.79) was significantly higher than those in the TC (*M* = 18.80, *SD* = 11.67), $t(53) = 2.12$, $p<.05$. This result holds true for the problem on development of pest resistance. Incremental score of the LC (*M* = 22.91, *SD* = 11.0) was higher than the TC (*M* = 17.20, *SD* = 11.67). This difference, however, was only marginally significant, $t(53) = 1.81$, $p<.10$.

Results of the phenomenographic analysis showed improvements of the students' conception of the problems during the post-test. However, misconceptions were still prevalent, especially among students in the TC group. The situation was, however, different in the LC group. For example, the central theme of the discussion on sedimentation was that sedimentation is caused by erosion and that eroding particles are deposited in waterbodies and low-lying areas. Erosion, according to them, results from clearing and cutting of trees and other vegetative cover to give way to farming. Their understanding, however, was yet incomplete as this did not include the discussion of the impact of this problem on fish productivity. However, during the pre-test, students thought that sedimentation is caused by changes in the soil's physical and chemical properties, inappropriate timing of cultivation; that is, farmers cultivate the farm during rainy season, and by soil erosion. Among these conceptions, only the latter fell within the scientifically accepted category. In this conception, students insisted that this problem begins with the cutting of trees and other vegetation. Thus, when rain comes, nothing traps the falling raindrops.

A similar trend was observed for the problem on eutrophication. Although the level of details varied, the post-test answers focused on the fact that the problem is caused by algal bloom which is triggered by nutrient enrichment. The nutrients, the

Table 2.
Typical examples of students' explanations of the problems on sedimentation, eutrophication and development of pest resistance during the post-test.

Ecological problems	Teacher-centered	Learner-centered
Sedimentation due to the cultivation of hilly areas without the use of erosion control measures	Cultivation of hilly areas can cause sedimentation because when the rain comes, heavy or not, the nutrients present in that area will be run-off. The nutrient goes to the rivers or seas.	Cultivation of hilly areas can cause sedimentation because this makes the soil bared and exposed. The falling raindrops could break the structure of the topsoil. Particles will then be washed and result in clogging of pores and soil particles will be carried down to the water bodies.
Eutrophication due to excessive inorganic fertilizer application	Eutrophication is the washing of fertilizer to the bodies of water, resulting in algal bloom. There is no dissolved oxygen because there is no photosynthesis. Thus, fish kill will occur.	Excessive use of inorganic fertilizer can cause eutrophication because some of the fertilizers will be carried away to the rivers and lakes, leading to the rapid growth of algae and phytoplanktons. Photosynthesis underwater will not be possible and there'll be no oxygen production. In this case, fish and other forms of life will be affected.
Development of pest resistance due heavy pesticide spraying	Pests which are very resistant will be retained and reproduce and the sensitive insects will diminish. This gives better chances for the resistant pests to multiply because they are already used to the pesticides applied.	Heavy pesticide spraying can lead to the development of resistance by insect pests because it is only the less resistant insects that will be affected while the pests with stronger resistance will not be affected. The resistant pests will then continue to breed.

students said, come from the fertilizers that are washed to the waterbodies. Interestingly, some of the explanations already covered the ill-effects of the problems – that is, reduction of fish productivity. In the pre-test, however, students' answers veered away from the scientific explanations. These conceptions included the belief that eutrophication is caused by soil acidity, depletion of the natural soil fertility due to fertilizer application, and production of noxious gases in the marine environment, thus causing toxicity. The only conception that fell within the scientifically accepted explanation was that, this problem is caused by algal bloom, a phenomenon triggered by the accumulation of fertilizer in the bodies of water.

As in the pre-test, students during the post-test still thought that the problem on development of pest resistance is caused by death of sensitive population and retention of the more resistant ones and immunity. Interestingly, many of the students now thought that the problem is caused by the former, not the latter, unlike in the pre-test (see Table 2).

Learning experiences

Results showed that while students in the TC group described their learning in terms of surface approaches – watching the videos, listening to the teacher's summary, taking down notes and less of analysis, those in the LC group described their experiences in terms of deep approaches. Accordingly, by requiring them to answer the problem embedded in the videos, learning was not spoon-feeding. They were then challenged to explore information – that is, consult with the teacher and read the handouts and other materials provided. They also felt empowered as they were given the chance to manage their own learning. Finding the solution to the challenges encouraged them to come up with their own ideas even if these were contrary to the teacher's opinion. Moreover, the challenges led them to use the knowledge they have learned from other subjects and even their experiences outside the classroom.

DISCUSSION

Data showed that in the three ecological problems studied, the mean incremental score of the students in the learner-centered group was consistently and significantly higher than those in the teacher-centered group. This increase could be attributed to the nature of learning that these students had experienced. First, learning in the LC classroom was generative; students generated sub-questions and formulated answers on their own. Based on previous works (CTGV, 1992, 1994, 1996; Wilson, 1996), these processes engage students in argumentation and reflections, enabling them to refine their existing knowledge, leading them to overcome their misconceptions and deepen their understanding of the lesson being studied. The other group did not have this opportunity.

The other reason could be the fact that students in the learner-centered group were engaged in collaborative learning. Collaborative learning, according to Singhanayok and Hooper (1998), stimulates students to discuss, debate, diagnose, and ultimately to teach one another.

The findings showing group differences in terms of learning experiences point out the role played by learning experiences in the improvement of students' learning outcomes during the post-test. As shown in the data, the teacher-centered environment tended to induce information absorption, and the learner-centered environment, knowledge construction. In the literature (e.g., Gravoso et al. 2002; Ramsden, 1992; Prosser & Trigwell, 1999; Richardson, 2000), it is generally agreed that if students perceive their learning situation as affording them with deep understanding, they adopt learning strategies that lead them to understand the subject matter better and to memorize concepts mechanically if the learning environment affords superficial learning. As argued earlier, memorization of information is a hallmark of poor quality learning.

As noted in the phenomenographic analysis, misconceptions of the problems were still dominant during the post-test. This can be explained by related research findings that as personal constructions, misconceptions are resistant to change (e.g., Mason, 2001; Brown, 1992). However, based on the conceptual change in the teacher-centered and learner-centered groups, it seems obvious that a student-centered learning environment that engages students in problem exploration has the potentials of overcoming deeply rooted misconceptions. On the other hand, learning characterized by passive reception of information as exemplified by this study's teacher-centered learning environment, is sadly inadequate to counter persistent erroneous conceptions. Thus, like the previous study involving the use of video materials to improve students' understanding of plant diseases (Palomar & Gravoso, 2006), findings of this study recommends the use of the constructive approach to learning. This position is espoused in the mental model repair (Chi, 2000) and the knowledge-in-pieces (diSessa, 1993; Ueno, 1993; Smith, diSessa, & Rochell, 1993; Hammer, 1996) views. The former postulates that it is constructive, and not didactic instruction that is more effective in leading students to fix or repair interpretations that contradict the accepted conceptions. Accordingly, the constructive approach encourages students to reflect on their learning, thus leading them to detect inconsistencies and violations between their mental models and normative model. On the other hand, the knowledge-in-pieces view holds that knowledge is malleable and can, therefore, be expanded. However, the transmission mode of instruction, which aimed to replace misconceptions, is insufficient to improve students' fragmented understanding. Accordingly, a more effective strategy is to provide students with an opportunity to discover for themselves the gap between their understanding and the scientific conceptions. The approach taken by the learner-centered group is a good example.

It should be emphasized, however, that students who studied through the teacher-centered learning environment also showed improvement in their learning outcomes. This increase means that students are able to learn any information regardless of the way by which they encounter the lesson. Comparing, however, the improvement of the teacher-centered and learner-centered groups, the former group's improvement was much less than the latter. It can be deduced that the manner by which the information was learned was responsible for the difference. This corroborates with Morrison's (1994) conclusion from his analysis of educational media projects that it is not the capabilities of media that facilitate learning but the creative development of instructional strategy which actively engages the learners. In terms of instructional design practice, this result highlights the fact that mere provision of a mass of information to the learners does not necessarily result in quality learning.

The above results are also consistent with the claim made by Clark about two decades ago (Clark, 1983) that continues to be echoed in educational media research these days (see 1994; Clark & Salomon, 1986; Clark & Sugrue, 1996). According to Clark, it is the instructional methods, not media that affect student achievement. In this study, a single medium was used and learning was carried out in two ways: transmission of information and problem exploration in a teacher-centered and learner-centered learning environments, respectively. If this position were false, there would have been no significant differences between the conceptual changes and understanding scores of the students in the traditional and problem-solving groups.

On the whole, although improvement of learning outcomes of students in the learner-centered group was still at a modicum level, findings of this study suggest that designing and using for use in a learner-centered learning environment where students are engaged in active learning results in better quality learning than when they are used to support teacher's efforts to transmit information

This study, however, has given rise to a number of questions. Firstly, due to time limitation, this study could only be conducted within three weeks, making it impossible to look at other aspects of learning outcomes. For instance, in this study, the variable learning outcomes was measured through students' written explanations. Thus, it will be interesting to find out if similar results would be obtained if this variable were measured via concept maps and influence diagrams.

Another facet is on the problem-solving transfer. More specifically, the following questions are worth pursuing: 1) Will the amount of assistance needed by the students decrease after longer exposure to a learner-centered environment? 2) Will students' exposure to the learner-centered approach change their daily study approaches? 3) After their exposure to a learner-centered learning environment for a relatively longer period of time, will students' problem-solving behavior differ from those who will study through the teacher-centered approach?

REFERENCES

Allen, J. (1996). Learning outcomes in higher education. *Studies in Higher Education*, *21*, 93-108.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (2000). *How people learn: Brain, experience, and school*, Washington, D.C.: National Academy Press.

Bransford, J. D. Franks, J. J., Vye, N. J., & Sherwood, R. D. (1989). New approaches to instruction: Because wisdom can't be told. In S. Vosniadou & A. Ortony (Eds.), *Similarity and analogical reasoning* (pp. 470-479). Cambridge: Cambridge University Press.

Brown, D. E. (1992). Using examples and analogies to remediate misconceptions in physics: Four factors influencing conceptual change. *Journal of Research in Science Teaching, 29*, 17-34.

Bruer, J. T. (1994). *Schools for thought: A science of learning in the classroom*, Cambridge: The MIT Press.

Burgess, T. (2000). The logic of learning and its implications for higher education. *Higher Education Review*, *32*, 53-65.

Chi, M. T. H. (2000). Self-explaining expository texts: The dual process of generating inferences and repairing mental models. In R. Glaser (Ed.), *Advances in instructional psychology—Volume 5: Educational design and cognitive science* (pp. 161-238). Mahwah, NJ: Erlbaum

Clark, R.E. (1994). Media will never influence learning. *Educational Technology Research and Development*, *42*, 21-29.

Clark, R. E. & Salomon, G. (1986). Media in teaching. In M.C. Wittrock (Ed.), *Handbook of Research on Teaching* (pp. 464-478). New York: Simon & Schuster Macmillan.

Clark, R.E. & Sugrue, B.M. (1996). Research on instructional media, 1978-1988. In G. J. Anglin (Ed.), *Instructional technology: Past, Present and Future* (pp. 336-346). Englewood, CO: Libraries Unlimited.

Cognition and Technology Group at Vanderbilt. (1992). The Jasper Experiment: An exploration of issues in learning and instructional design. *Educational Technology Research and Development*, *40*, 65-80.

Cognition and Technology Group at Vanderbilt. (1994). Designing learning environments that support thinking: The Jasper series as a case study. In T. M. Duffy, J. Lowyck, & D. H. Jonassen (Eds.), *Designing environments for constructivist learning* (pp. 9-36). Berlin: Springer.

Cognition and Technology Group at Vanderbilt (1996). *The Jasper project: Lessons in curriculum, instruction, assessment, and professional development*. Mahwah, NJ: Lawrence Erlbaum Associates.

Conway, G. R. & Barbier, E. B. (1990). *After the green revolution: Sustainable agriculture for development*. London: Earthscan.

Conway, G. R. & Pretty, J. N. (1991). *Unwelcome harvest: Agriculture and pollution*. London: Earthscan.

diSessa, A.A. (1993). Toward an epistemology of physics. *Cognition and Instruction*, *10*, 239-249.

Edelson, D., Pea, R., & Gomez, L. (1996). *Constructivism in the collaboratory.* In B. G. Wilson (Ed.), *Constructivist Learning*

Environments: Case Studies in Instructional Design (pp. 151-164). Englewood Cliffs, NJ: Educational Technology Publications.

Ely, O. P. & Gerlach, V. S. (1981). *Teaching and media: A systematic approach*. Englewood Cliffs, NJ: Prentice-Hall.

Gagne, R. M. & L. J. Briggs. (1979). *Principles of instructional design*. New York: Holt, Rinehart and Winston.

Gravoso, R. S., Pasa, A. E. & Mori, T. (2002). Influence of students' prior learning experiences, conceptions of learning and study approaches on their learning outcomes. In A. Goody, J. Herrington, & M. Northcote (Eds.), *Research and development in higher education: Volume 25–Quality conversations* (pp. 282-289). ACT: Higher Education Research and Development Society of Australasia.

Hammer, D.H. (1996). Misconceptions on p-primes: How many alternative perspectives of cognitive structure influence instructional perceptions and intentions? *The Journal of the Learning Sciences*, *5*, 97-127.

Heinich, R. M., Molenda, M., Russel, J. D., & Smaldino, S. (1996). *Instructional media and technologies for learning*. NJ: Prentice-Hall.

Jonassen, D. H., Peck, K. L., & Wilson, B. G. (1999). *Learning with technology: A Constructivist Perspective*. Upper Saddle River, NJ: Merill.

Kemp, J. E. (1977). *Instructional design: A plan for unit and course development*. Belmont, CA: Fearon-Pitman.

Lambert, N. M., & McCombs, B. L. (1995). Introduction: Learner-centered schools and classrooms as a direction for school reform. In N. M. Lambert & B. L. McCombs (Eds.), *How students learn: Reforming schools through learner-centered education* (pp. 1-23). Washington, D.C.: American Psychological Association.

Marton, F. & Booth, S. (1996). The learner's experience of learning. In D. Olson & N. Torrance (Eds.), *The handbook of education and human development: New models of learning, teaching and schooling* (pp. 534-564). Cambridge: Blackwell.

Mason, L. (2001). Introducing talk and writing for conceptual change: A classroom study. *Learning and Instruction*, *11*, 305-329.

Morrison, G. R. (1994). The media effects question: "Unresolvable" or asking the right question. *Educational Technology Research and Development*, *42*, 41-44.

Nebel, B. J. & Wright, R. T. (1996). *Environmental science: The way the world works*, NJ: Prentice-Hall.

Palomar, E. R. M. S. & Gravoso, R. S. (2006). Effects of a video-mediated student-centered learning environment on student's understanding of basic plant pathology principles. *Annals of Tropical Research*, *28*(2), 32-52.

Prosser, M. & Trigwell, K. (1999). *Understanding learning and teaching: The experience in higher education*. Burckingham: SRHE & Open University Press.

Ramsden, P. (1992). *Learning to teach in higher education*. London: Routledge.

Richardson, J. T. E. (2000). *Research student learning: Approaches to studying in campus-based and distance education*. Buckingham: SRHE & Open University Press.

Sakamoto, T. (1996). Development of educational technology contributing to educational reform. *Educational Technology Research*, *19*, 1-21.

Singhanayok, C. & Hooper, S. (1998). The effects of cooperative learning and learner-control on students' achievement, option selections, and attitudes. *Educational Technology Research and Development*, *46*, 17-33.

Schank, R. C., Berman, T. R., & Macpherson, K. A. (1999). Learning by doing. In C. M. Reigeluth (Ed.), *Instructional-design theories and models: A new paradigm of instructional theory* (pp. 161-181). Mahwah, NJ: Erlbaum.

Smith, J.P. di Sessa, A.A., & Rochelle, J. (1993). Misconceptions reconceived: A constructivist analysis of knowledge in transition. *The Journal of the Learning Sciences*, *32*, 115-163.

Ueno, N. (1993). Reconsidering p-prime theory from the viewpoint of situated cognition. *Cognition and Instruction*, *10*, 239-249.

Wang, Q., & Woo, H. L. (2007). Systematic planning for ICT integration in topic learning. *Educational Technology and Society*, *10*(1), 148-156.

Wilson, B. G. (1996). What is a constructivist learning environment? In B.G. Wilson (Ed.), *Constructivist learning environments: Case studies in instructional design* (pp. 3-8). Englewood Cliffs, NJ: Educational Technology Publishers.

Zucchermaglio, C. (1993). Toward a cognitive ergonomics of educational technology. In T. M. Duffy, J. Lowyck, & D. H. Jonassen (Eds.), *Designing environments for constructive learning* (pp. 249-260). Berlin: Springer.