Effects of different forms of physiology instruction on the development of students’ conceptions of and approaches to science learning

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Lin Y-H, Liang J-C, Tsai C-C. Effects of different forms of physiology instruction on the development of students’ conceptions of and approaches to science learning. Adv Physiol Educ 36: 42–47, 2012; doi:10.1152/advan.00118.2011.—The purpose of this study was to investigate students’ conceptions of and approaches to learning science in two different forms: internet-assisted instruction and traditional (face-to-face only) instruction. The participants who took part in the study were 79 college students enrolled in a physiology class in northern Taiwan. In all, 46 of the participants were from one class and 33 were from another class. Using a quasi-experimental research approach, the class of 46 students was assigned to be the “internet-assisted instruction group,” whereas the class of 33 students was assigned to be the “traditional instruction group.” The treatment consisted of a series of online inquiry activities. To explore the effects of different forms of instruction on students’ conceptions of and approaches to learning science, two questionnaires were administered before and after the instruction: the Conceptions of Learning Science Questionnaire and the Approaches to Learning Science Questionnaire. Analysis of covariance results revealed that the students in the internet-assisted instruction group showed less agreement than the traditional instruction group in the less advanced conceptions of learning science (such as learning as memorizing and testing). In addition, the internet-assisted instruction group displayed significantly more agreement than the traditional instruction group in more sophisticated conceptions (such as learning as seeing in a new way). Moreover, the internet-assisted instruction group expressed more orientation toward the approaches of deep motive and deep strategy than the traditional instruction group. However, the students in the internet-assisted instruction group also showed more surface motive than the traditional instruction group did.

conceptions of learning: approaches to learning

IN RECENT YEARS, considerable concern has arisen over students’ conceptions of and approaches to learning in different domains and situations (4, 33). The Internet has existed for over 30 yr, and there has been a dramatic proliferation of research concerned with its educational value (21). Moreover, internet-assisted instruction has been used in basic science courses for over 10 yr (20). Therefore, it is important to understand whether internet-assisted instruction contributes to the development of students’ conceptions of and approaches to learning science.

Säljö (24), the pioneer of research regarding conceptions of learning, defined “an increase of knowledge,” “memorizing,” “the acquisitions of facts, procedures that can be retained and/or utilized in practice,” “the abstraction of meaning,” and “an interpretative process aimed at the understanding of reality” as five major types of conceptions of learning. He led flourishing research on the conceptions of learning. In terms of subsequent research, Tsai (27) specifically considered the instructional characteristics in Taiwan and the conceptions of learning particularly directed to the domain of science. He defined seven conceptions of learning, namely, “memorizing,” “preparing for tests,” “calculating and practicing tutorial problems,” “increase of knowledge,” “applying,” “understanding,” and “seeing in a new way.” Tsai’s classification manifests that learners’ conceptions of learning may be influenced by the culture and knowledge domain under investigation. He also suggested that these conceptions could be viewed as a hierarchical structure, from lower level to higher level (27). That is, the first three conceptions can be treated as lower-level conceptions, whereas the latter four can be regarded as higher-level conceptions.

Approaches to learning have been defined as the ways in which learners process their academic tasks and influence their learning outcomes (19). Generally, there are two approaches to learning: surface (rote) and deep (meaningful) (22). According to Chin and Brown (3), deep and surface approaches are associated with different kinds of motivations and interest in the class or in the content of the task. They argued that surface approaches are related to learning through extrinsic and instrumental motivation, which comes from outside of the individual. In contrast, deep approaches are associated with intrinsic motivation, which occurs when students are internally motivated to do something because it either brings them pleasure, they think it is important, or they feel that what they are learning is significant.

At many universities in Taiwan, most curricula for non-science majors require students to take two or three science electives to graduate. Physiology is one of the major disciplines in science and is the study of life, specifically, how cells, tissues, and organisms function. Furthermore, physiology is an inherently complicated subject; therefore, physiology teachers need to conduct various methods of instruction for different types of students (7). Comprehension of physiology requires students to meaningfully retain facts and the competence to use those facts to deal properly with all kinds of complicated situations (26). In the science classroom, pedagogical choices influence student learning. Hence, when teaching physiology to non-science major students, using an innovative form of instruction that may enhance their learning motivation and promote positive learning outcomes is crucial.
Little research has been published on the conceptions of and approaches to learning science of students majoring in early childhood care and education. The present research focused on early childhood majors to develop an improved understanding of different aspects of students’ learning conceptions and approaches. Moreover, many will agree that science education should start at the level of early childhood education, and some scientific capabilities, such as observation, classification, and manipulation, are displayed from infancy (30). The undergraduate early childhood education students in Taiwan are preservice teachers for preschool children. Research has indicated that science teachers’ conceptions of learning and teaching may also play a role in students’ conceptions of learning science (27). For undergraduate early childhood education students, higher-level conceptions of learning are very important for their academic studies and their future teaching work.

The issue of how to promote students’ conceptions of learning science and their approaches to learning science remain an essential issue for science education (3, 14, 16, 17). The use of internet-based learning may have some potential to foster students’ conceptions of learning. Tsai (28) investigated the differences between students’ conceptions of learning and conceptions of internet-based learning by interviewing 83 Taiwanese college students. He found that their conceptions of Web-based learning were more sophisticated than their conceptions of learning in general. He therefore suggested that internet-based instruction may be effective in fostering students’ conceptions of learning.

Internet-assisted inquiry activities encourage students to learn autonomously and provide guidelines for exploring data, comparing resources, and identifying alternative explanations. In contrast to internet-assisted inquiry activities, traditional instruction assigns tasks prescribed by the teacher (10). Inquiry involves five essential features: engaging students in scientifically oriented questions, using evidence to respond to questions, formulating explanations based on evidence, connecting explanations to scientific knowledge, and communicating and justifying explanations (21a). Student satisfaction with the method of process-oriented guided learning has been shown to be high, and it has also been confirmed that most students perceive the value of this form of instruction (1). Moreover, with the advent of internet technology, many researchers have used computers and the internet to design a variety of inquiry learning activities (2). The use of internet inquiry activities in the physiology classroom as a research field has not yet been greatly explored. Therefore, to determine if the use of internet-assisted inquiry activities would improve the students’ conceptions of and approaches to learning science is paramount.

In the present study, through gathering questionnaire data from two physiology classes of early childhood major students in Taiwan, the effects of different forms of instruction on students’ conceptions of and approaches to learning science were evaluated by comparing their conceptions and approaches before and after the conduct of online inquiry activities.

**METHODS**

**Participants.** The participants who volunteered to take part in the study were 79 college students from 2 classes enrolled in a physiology class in north Taiwan. To ensure some homogeneity of their learning background, all participants were juniors (i.e., third-year students of undergraduate study). Using a quasi-experimental research approach, one gross of 46 students was assigned to the internet-assisted instruction group, whereas another class of 33 students was assigned to the traditional instruction group. They were all taught by the same physiology teacher. All participants were female and were majoring in early childhood care and preschool education; they were preservice preschool teachers. They were enrolled in the physiology course for an introduction to the development and health care of young children. For the participants in the experimental group, they all had experience with using the internet as well as basic skills in using computers.

**Instruments.** To assess the students’ conceptions of and approaches to learning science, two questionnaires were used: the Conceptions of Learning Science (COLS) questionnaire and the Approaches to Learning Science (ALS) questionnaire.

The COLS questionnaire was based on Tsai’s previous research (27) and was developed by Lee et al. (15). It included the following seven factors (with a sample item provided):

1. Memorizing: learning science means memorizing definitions, formulas, and important concepts and proper nouns; for example, learning science means memorizing scientific symbols, scientific concepts, and facts.
2. Testing: learning science to pass examinations and get high scores; for example, I learn science so that I can do well on science-related tests.
3. Calculating and practicing: learning science to put more emphasis on calculations, problem solving, and constant practice; for example, learning science means knowing how to use the correct formulas when solving problems.
4. Increasing one’s knowledge: learning science is regarded as acquiring more unknown scientific knowledge; for example, learning science means acquiring more knowledge about natural phenomena and topics related to nature.
5. Applying: the purpose of learning science is to apply scientific knowledge to improve the quality of our lives; for example, learning science means solving or explaining unknown questions and phenomena.
6. Understanding: learning science to achieve a true understanding of scientific knowledge; for example, learning science means understanding the connection(s) between scientific concepts.
7. Seeing in a new way: learning science means changing the way of viewing natural phenomena; for example, learning science helps me view natural phenomena and topics related to nature in new ways.

Lee et al. (15) further suggested that the first three conceptions can be treated as lower-level conceptions, whereas the latter four can be regarded as higher-level conceptions.

In this study, each factor had six to eight items and was presented in a 5-point Likert scale (where 1 = “strongly disagree” and 5 = “strongly agree”). The higher the scores gained in a certain category, the stronger the agreement there is for that factor in learning science. Lee et al. (15) conducted a series of exploratory and confirmatory factor analyses to validate the questionnaire. The original reliability (Cronbach’s α) coefficients for these factors ranged from 0.84 to 0.91, respectively, and the overall α was 0.91. Chiou and Liang (4) further validated the questionnaire with the seven proposed factors with α coefficients from 0.62 to 0.90. The reliability coefficients for these scales of this study ranged from 0.74 to 0.89. The α coefficient calculated from the sample of this study for the scales was ~0.82, which indicated satisfactory reliability of assessing students’ conceptions of learning science.

The ALS questionnaire was modified from the Revised Learning Process Questionnaire of Kember et al. (13) by Lee et al. (15). The instrument uses a multidimensional framework for showing students’ learning approaches, which includes the following four factor categories shown below (each with a sample item):

1. Deep motive: the student holds deep motives (i.e., feeling happy and satisfied) for learning science; for example, I feel that science topics can be highly interesting once I get into them.
2. Deep strategy: the student uses deep strategies of learning science (i.e., exploring the relationships between science concepts or other ideas); for example, I try to relate what I have learned in science subjects to what I learn in other subjects.

3. Surface motive: the student holds surface motives (i.e., fear of failure or teacher's expectations) for learning science; for example, I am discouraged by a poor mark on science tests and worry about how I will do on the next test.

4. Surface strategy: the student uses surface strategies of learning science (i.e., learning by narrowing targets); for example, I find the best way to pass science examinations is to try to remember the answers to likely questions.

Each factor included six to nine items. All of the items were presented in a 5-point Likert scale (where 1 = “never” and 5 = “always”). The original reliability (Cronbach's $\alpha$) coefficients for these factors were 0.90, 0.89, 0.84, and 0.84, respectively, and the overall $\alpha$ was 0.89. In addition, the coefficient from the sample of this study was $-0.62$–$0.95$ for each scale. According to Hatcher and Stepanski (11), an $\alpha$ value as low as 0.55 should be statistically considered as acceptable. Therefore, the reliability for this study was sufficient for statistical analysis.

All of the participants responded to the two questionnaires both before and after the traditional instruction and internet-assisted instruction. The questionnaire data, after the students’ agreement, were collected in paper and pencil format.

Research treatment: online inquiry activities. In the internet-assisted instruction group, a Chinese textbook, *Child Physiology*, was used as the course guideline. The same textbook was used for the traditional instruction group. Moreover, the students in the internet-assisted instruction group were assigned some online searching tasks that were associated with some issues listed in the textbook after almost every physiology class period. For example, they were asked to explore some biology, physiology, or anatomy knowledge taught in the course by finding more related knowledge or information on the internet. In some cases, if necessary, students were asked to search the internet for information to resolve some controversial issues immediately in the class, and they also participated in some traditional or online discussions and debates. For example, there is always a fierce debate on the usage of medicines or therapy (antibiotics, steroids, etc.) for children’s diseases. Therefore, along with the physiology course instruction for the lesson unit on children’s diseases, each student was asked to answer the following questions by searching for online resources:

- What are the basic physiological concepts or principles related to medicines, especially antibiotics or steroids, for young children?
- What is the frequency of utilization of antibiotics or steroids by pediatricians in Taiwan?
- List the advantages and disadvantages of using antibiotics or steroids in the treatment of young children.
- When is the right time to prescribe antibiotics or steroids?
- Do you support the usage of antibiotics or steroids when children catch colds? And what is your reason?

All questions were answered by e-mail to the physiology teacher as the homework to prepare for the online debates. A series of such online inquiry activities was completed over a period of $\sim 3$ mo, and the participants were asked to elaborate on their scientific knowledge related to physiology through online resources while being simultaneously engaged in some online inquiry explorations. For example, with regard to medication, the teacher asked the students whether they agreed with the use of steroid ointment on young children. This first step provided an opportunity for students to be involved in scientifically oriented questions, so they did not simply follow the knowledge generated by the textbook or the instructor. After the students declared their own stance, they were asked to explore related information to support their own contentions on the internet. Furthermore, the students were asked to discuss or debate the information they found on the internet. The inquiry activities encompassed essential features such as engaging students in scientifically oriented questions, providing them with the ability to use evidence in responding to questions, synthesizing what they had learned, and debating their arguments, as proposed by National Research Council (21a). These activities (e.g., searching for information on the internet, discussion, and debates) were incorporated in the regular classes of the physiology course.

On the other hand, in the traditional instruction group, textbooks and one-way lecturing were mainly used. Students in the traditional instruction group were provided with *Child Physiology* textbook and followed the book chapters to acquire physiological knowledge. According to the book chapters, the teacher made PowerPoint slides as a teaching aid. Lectures, note taking, and recall of obtained knowledge constituted the major instruction activities.

By and large, both the traditional instruction group and internet-assisted instruction group used the same textbook. The major difference between two groups came from the arrangement of learning activities. In the traditional instruction group, lectures, note taking, recall of obtained knowledge, and quizzes occupied most ($\sim 90\%$) of the instructional time. In the internet-assisted group, $\sim 50\%$ of the time was devoted to lectures and $25\%$ for peer discussion and debate regarding the related information from internet, and for the rest of the time ($25\%$), the instructor analyzed and synthesized the information from both the textbook and the internet.

RESULTS

Means (and SDs) for the students’ conceptions of learning science before and after the internet-assisted instruction are shown in Table 1.

In this study, one-way analysis of covariance (ANCOVA) was used to examine whether any significant difference existed in the two groups of students’ conceptions of learning science after the treatment. Students’ conceptions of learning science before conducting the treatment were used as the covariates and the student’s conceptions of learning science after conducting the treatment were used as the dependent variables. The adjusted means (and SEs) for the two groups of students’ conceptions of learning science after completing the internet-assisted instruction are shown in Table 1 as well.

The results of ANCOVA revealed that the students in the traditional instruction group obtained significantly higher scores in the lower-level conceptions, such as memorizing ($F = 4.52, P < 0.05, \eta^2 = 0.06$) and testing ($F = 18.63, P < 0.001, \eta^2 = 0.20$). There was a medium effect between the two groups on the conceptions of testing, as indicated by a partial $\eta^2$ value of 0.20. On the other hand, students in the internet-assisted instruction group significantly outperformed the other group in the higher-level conceptions, namely, the factor of seeing in a new way ($F = 20.18, P < 0.001, \eta^2 = 0.22$). A medium effect was found between the internet-assisted inquiry instructional group and the traditional teaching group for the conceptions of seeing in a new way, as indicated by a partial $\eta^2$ value of 0.22.

The findings above imply that, compared with traditional instruction, internet-assisted instruction significantly helped the students to obtain higher-level conceptions of learning science.

Similarly, this study assessed how internet-assisted instruction may have effects on the students’ approaches to learning science. Means (and SDs) for the students’ approaches to learning science are shown in Table 2.
One-way ANCOVA, using pretest scores as the covariates, was also used to examine whether any significant difference existed in the two groups of students’ approaches after the treatment. The adjusted means for the two groups of students’ approaches to learning science after completing the internet-assisted instruction are shown in Table 2.

Students in the internet-assisted instruction group significantly outperformed the other group in the approaches of deep motive \((F = 20.46, P < 0.05, \eta^2 = 0.21)\) and deep strategy \((F = 18.64, P < 0.001, \eta^2 = 0.20)\). There was a medium effect between the internet-assisted inquiry group and the traditional teaching group on the approaches of deep motive and deep strategy, as indicated by partial \(\eta^2\) values of 0.21 and 0.20. That is, internet-assisted instruction significantly helped the students to use deep approaches to learning science. However, students in the internet-assisted instruction group also obtained significantly higher scores in the approaches of surface motive \((F = 4.86, P < 0.05, \eta^2 = 0.06)\), but the effect was weak, as indicated by a partial \(\eta^2\) value of 0.06.

**DISCUSSION**

The present study evaluated the effects of two different forms of instruction in a physiology course on students’ conceptions of and approaches to learning science. First, the students’ conceptions of learning science were examined. We found that the students in the internet-assisted instruction group attained lower scores than the traditional instruction group in the conceptions of memorizing and testing. That is, the students in the internet-assisted instruction group were inclined to

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<th>Table 1. Descriptive statistics of students’ pretest and posttest scores and ANCOVA summary of students’ conceptions of learning science</th>
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There were 46 students in the internet-assisted instruction group and 33 students in the traditional instruction group. ANCOVA, analysis of covariance. \(*P < 0.05\).

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<th>Table 2. Descriptive statistics of students’ pretest and posttest scores and ANCOVA summary of students’ approaches to learning science</th>
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There were 46 students in the internet-assisted instruction group and 33 students in the traditional instruction group. ANCOVA, analysis of covariance. \(*P < 0.05\).
express less agreement with the conceptions of memorizing and testing. Research has indicated that in the traditional instruction classroom, class periods are lecture based and involve note taking, usually through the use of a chalkboard or whiteboard. Consequently, it is expected that students will answer questions generated by their teachers (25). To memorize definitions, formulas, laws, and special terms from the textbook are characteristics of learning science in traditional instruction. The results suggest that traditional instruction may highly value memorizing. However, with the development of technology, in addition to attending lectures and reading texts, students can apply different options for acquiring knowledge, such as iPod downloads and surfing the internet (32). Therefore, the conception of memorizing may have declined in the internet-assisted instruction group.

Moreover, in Taiwan, test scores are often emphasized by teachers, parents, and students as well. For students in Taiwan, their performance on tests is the decisive factor of their advanced study (27, 29); even undergraduate students still care greatly about their test scores. Therefore, tests continue to play a role in students’ conceptions of learning science. Especially in traditional instruction, teaching and learning may be test oriented. In contrast, in an internet-assisted inquiry instruction environment, instruction focuses more on the learning process. In other words, evaluation does not mainly rely on the students’ test performance. As a result, students in the internet-assisted instruction group expressed less agreement with the conception of testing than their counterparts did.

The online inquiry activities conducted in the present study functioned as the element of influencing or changing the students’ conceptions of learning science. Evidence derived from previous studies has displayed the benefits of online inquiry activities in higher education (9). Online inquiry can promote students’ motivation, extend their knowledge, and help to elaborate on their own comprehension (8). Therefore, internet-assisted instruction that relies primarily on online inquiry activities may account for students having less agreement with the conceptions of memorizing and testing.

In terms of higher-level conceptions, we found that the students in the internet-assisted instruction group significantly outperformed the traditional instruction group in the conception of seeing in a new way. This finding indicates that internet-assisted instruction is useful for students to acquire different perspectives of some phenomena. In the present study, students in the internet-assisted instruction group were asked to answer practical questions and take part in online debates. The science knowledge attained through the internet-assisted instruction may be more extended with greater variations; therefore, students in the internet-assisted instruction group expressed more agreement with the idea of learning as seeing in a new way (28). In other words, the students’ conceptions of learning science may be improved by such internet-assisted science instruction. The above-mentioned results also verify those of a previous study (28) that found that students’ conceptions of internet-assisted instruction are more sophisticated than those of students learning in traditional instruction and focus on higher-level factors, such as seeing in a new way. However, variations of science knowledge in the world of the internet may cause other difficulties for learners, such as the ability of judging online information related to science (18) or information overload (12).

In addition, students in the internet-assisted instruction group significantly outperformed the traditional instruction group in terms of deep motive and deep strategy for their approaches to learning science. Previous studies (5, 15) have revealed that the higher level conceptions of learning science that the students hold, the deeper the approaches to learning science they use. Moreover, students’ knowledge construction and meaningful learning can be improved through inquiry-oriented or internet-assisted instruction activities (23). In the internet-assisted instruction environment, the more sophisticated conceptions of learning the students have, the better learning approaches they may adopt (28). Therefore, it is expected that the approaches of deep motive and deep strategy would be better expressed in the internet-assisted instruction group.

Nevertheless, the internet-assisted instruction group also obtained significantly higher scores than the traditional instruction group in the approaches of surface motive (e.g., fear of failure). That is, students in the internet-assisted instruction group worried about their performance in the science class in that they were worried that they could not meet the teacher’s expectations. Compared with traditional instruction, internet-assisted instruction is relatively novel, and it is possible that the students were unable to anticipate what the test content would be and how their performance would be evaluated. However, in this study, there was only a weak (although positive) effect of the internet-assisted instruction on the approach of surface motive.

The present study analyzed a group of college students’ conceptions of and approaches to science learning. Integrating Internet learning activities into the curriculum is a current instructional trend; therefore, the next issue that educators face is how to cultivate students’ higher level conceptions through Internet-assisted instruction. This study suggests that Internet-assisted instruction may facilitate students’ higher level conceptions and further help students employ deep motive and deep strategy.

Internet-assisted inquiry instruction has been identified with several characteristics that promote students’ concept learning in science, such as questioning, data analysis, and critical thinking. However, the science knowledge that exists on the internet requires students to judge its value. Consequently, the instructor should develop students’ information search competence when conducting internet-assisted inquiry activities (31).

Even though the present study has the merit of offering valuable insights into internet-assisted instruction for physiology, it has some limitations. This study was limited to a group of college students. It would be beneficial to replicate this study with larger and different populations. Moreover, to obtain more reliable and objective data, future research can gather qualitative data from students. Qualitative data might be to consider whether the students themselves feel that their conceptions of and approaches to learning science benefit more from internet-assisted instruction.

**GRANTS**

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**DISCLOSURES**

No conflicts of interest, financial or otherwise, are declared by the author(s).
AUTHOR CONTRIBUTIONS

Y.-H.L. and J.-C.L. analyzed data; Y.-H.L. and J.-C.L. interpreted results of experiments; Y.-H.L., J.-C.L., and C.-C.T. approved final version of manuscript; J.-C.L. and revised manuscript; Y.-H.L., J.-C.L., and C.-C.T. performed experiments.

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