LOOK ACADEMIC PUBLISHERS
OPEN ACCESS

INTERNATIONAL JOURNAL OF ENVIRONMENTAL & SCIENCE EDUCATION
2017, VOL. 12, NO. 8,1871-1878

The Effectiveness of Question-Based Inquiry Module in Learning Biological Knowledge and Science Process Skills

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ABSTRACT

Knowledge and science process skills are important in the science classroom. Science processes are thinking processes that foster lifelong learning. In inquiry-based science learning, students are engaged in many of the activities and thinking processes that scientists use to produce new knowledge. The inquiry approach can be implemented effectively with the use of questions leading to an investigation through which students learn to understand the content of the subject. This study investigated the effectiveness of a question-based inquiry module (QBIM) for learning biological knowledge and science process skills. The research participants were 34 eight graders of junior high school. The results showed biological knowledge and science process skills of students were mostly in the good category. The effectiveness index (EI) of biological knowledge and science process skills were 85.29 % and 79.41% respectively. The students' responses to the implementation of QBIM were positive. The students stated that they enjoyed learning biology (91.18%), the learning was considered attractive (97.06%), the module was easy to learn (85.29%), the tasks were challenging (85.29%), and the assessment was good (97.06). QBIM was an effective medium for teaching biological knowledge and science process skills. The findings of this study also pointed out the students' positive responses to the QBIM-based science learning.

KEYWORDS
inquiry, question, module, Biological knowledge, science process skills

ARTICLE HISTORY
Received 11 September 2017
Revised 13 October 2017
Accepted 19 October 2017

Introduction

Learning science is essentially the study of nature by means of scientific methods. Students, therefore, need to have learning experiences to develop their knowledge, science process skills, and scientific attitudes through inquiry. In the inquiry process, students are active constructors of knowledge, and the teacher is a facilitator of their learning (Chu et al., 2011). Gormally et al. (2009) and Minner et al. (2009) describe that inquiry-based science learning can encourage literacy, science process skills, and improve the learning activity and concept

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understanding. Rose & Colin (1997) state that learning is a lifelong adventure. It's a never-ending voyage of exploration to create your own personal understanding. Teachers should enable students to learn how to learn. Learning how to learn is very beneficial for students since this allows for lifelong learning. Futurologists believe that the future belongs to those who are able to continue practicing and learning.

Inquiry is a way of learning the content of the curriculum and an approach to teaching and learning–sometimes called inquiry-based learning, or discovery learning, or inquiry-based teaching (Kuhlthau et al., 2007:5; Goldman *et al*., 2010). When inquiry-based learning is incorporated into instruction, teachers provide guiding questions for students to actively explore the required knowledge in order to solve the problems (Wu et al., 2015). Simsek & Kabapinar (2010) found that inquiry-based learning had a positive impact on students' conceptual understanding and scientific process skills. Inquiry-based teaching allows students to learn content and process at the same time (Woolfolk, 2011:385). Furthermore, the activities of science process skills can be linked to creative thinking (Thomson, 2017). The *National Science Education Standards* characterizes inquiry instruction as involving students in a form of active learning that emphasizes questioning, data analysis, and critical thinking (Bell, et al., 2005)

Questions are the core or the heart of scientific inquiry and foundation of teaching and learning. Inquiry-based learning requires questions leading to an investigation through which students learn to understand the content of the subject. Questions are among the most powerful teaching tools that can significantly enhance the quality of instruction (Tofade et al., 2013). Students' questions in "reading an object" can be used to develop effective scientific inquiry (Haynes-Berry & Berry, 2014). Teachers' questions can serve a variety of purposes, such as managing the classroom, reinforcing a fact or concept, stimulating thinking, arousing interest, and helping students develop a particular mind-set (Martin et al., 2005).

Learning science in junior high school is emphasized more on learning experience and discovering science knowledge rather than on memorizing. Both subject matter content and process skills are needed for learning mastery in science (Carin, 1993:62). Therefore, students need to have science process skills and scientific attitude in learning science. Inquiry-based instruction can be used as an alternative strategy in the science classroom. Dostal (2015) states that inquiry-based instruction is an activity of a teacher and a pupil that is focused on the development of knowledge, skills and attitudes based on active and relatively individual cognition of the reality by the pupil who learns on his/her own how to explore. The inquiry/discovery approach is effective both for teaching science content and developing inquiry "process" skills (Sutman et al., 2007:62). Inquiry is often defined as a search for truth, information, or knowledge. The search efforts are conducted through questions. Accordingly, in this study, to facilitate students' learning of science concepts and science process skills, a question-based inquiry module (QBIM) was utilized.

Methods

The study was carried out as part of a research and development project on a question-based inquiry module (QBIM) development. The question-based inquiry module was developed by following ADDIE model of instructional design which includes such five stages as: analysis, design, development and production, implementation, and evaluation (Colston, 2012; Kruise, Maskha, 2002; Molenda, 2003). The QBIM was implemented to 34 eight graders of junior high school. There were eight sets of module utilized in this study, as summarized in Table 1.

Table 1. Summary of Question-based Inquiry Module (QBIM)

Inquiry Topic	Objectives	
	Science Process skills	Knowledge
1.Why does bone become hard?	Hypothesizing, Observing, Communicating, Comparing, Inferring	The main composition of bones
2. Do we need the joint?	Observing, Comparing Inferring	The importance of joint
3. How are the characteristics of muscle?	Observing, Measuring, Comparing, Inferring	Characteristics of muscle contraction
4. How is the structure of human skeleton?	Observing, Comparing, Inferring	The structure of human skeleton
5. What are the mechanical and chemical digestion?	Observing, Communicating, Comparing, Inferring, Experimenting	The process of mechanical and chemical digestion
6. Which food contains starch?	Observing, Communicating, Inferring	The foods that contain starch
7. Which food contains fat?	Observing, Communicating, Inferring	The foods that contain fat
8. Which food has the most vitamin C?	Observing, Communicating, Comparing, Inferring	The fruits that contain vitamin C

The lesson sequence conducted in the implementation of QBIM was as Table 2.

Table 2. The Lesson Sequence QBIM-based Teaching and Learning

No.	Lesson Phase	Activities
1	Pre-Laboratory Phase	1) Asking questions proposed to be studied 2) Discussing about investigative procedure
2	Laboratory Phase	1) Activity or experiment is carried out 2) Evidence or data are collected or observed 3) Data or results are analyzed
3	Post-Laboratory Phase	1) Answering questions 2) Summarizing or drawing conclusion

The effectiveness of the use of QBIM in this study was analyzed descriptively based on the effectiveness index (EI) and the student's response. Effectiveness index (EI) represents the percentage of learners reaching a preset level of mastery and the average percentage of the objectives met by all learners (Morrison et al., 2007:320). The effectiveness index (EI) used in this study was 85% for mastery of biological knowledge and 75% for science process skills.

Table 3. Summary of Question-based Inquiry Module (QBIM)

Inquiry Topic	Objectives	
	Science Process skills	Knowledge
1.Why does bone become hard?	Hypothesizing, Observing, Communicating, Comparing, Inferring	The main composition of bones
2. Do we need the joint?	Observing, Comparing Inferring	The importance of joint
3. How are the characteristics of muscle?	Observing, Measuring, Comparing, Inferring	Characteristics of muscle contraction
4. How is the structure of human skeleton?	Observing, Comparing, Inferring	The structure of human skeleton
5. What are the mechanical and chemical digestion?	Observing, Communicating, Comparing, Inferring, Experimenting	The process of mechanical and chemical digestion
6. Which food contains starch?	Observing, Communicating, Inferring	The foods that contain starch
7. Which food contains fat?	Observing, Communicating, Inferring	The foods that contain fat
8. Which food has the most vitamin C?	Observing, Communicating, Comparing, Inferring	The fruits that contain vitamin C

Thus, the minimum completeness criteria (MCC) for mastery of biological knowledge and science process skills were 80 and 75 respectively.

Results

The results of the study were based on the descriptive statistical analysis of the results of the cognitive test and performance assessment as shown in Table 4. Table 4 shows that mastery of biological knowledge and science process skills were in the good category and the details are presented in Table 5.

Table 4. Descriptive Data of Students' Biological Knowledge and Science Process Skills

Aspects	Mean	SD	EI
1. Biological knowledge	81.24	8.82	85.29%
2. Science Process Skills	79.61	7.55	79.41%

Table 5. Data of Biological Knowledge and Science Process Skills (n=34)

Scores	Categories	Biological Knowledge		Science Process Skills	
		fo	%	fo	%
85-100	Excellent	13	38.24	12	35.29
70-84	Good	18	52.94	17	50.00
55-69	Average	3	08.82	5	14.71
40-54	Fair	0	0	0	0
00-39	Poor	0	0	0	0

fo = frequency

Biological knowledge and science process skills of students were mostly in the good category. The effectiveness index (EI) of biological knowledge and science process skills were 85.29 % and 79.41% respectively. These findings indicated that the use of QBIM was effective in improving the students' biological knowledge and science process skills.

A questionnaire was used to measure the students' response to the teaching and learning of science by using QBIM. The students' responses to the questionnaire are summarized in Table 6.

Table 6. Students Responses to QBIM-based Teaching and Learning (n=34)

Aspects	Response	fo	%
a. Implementation of learning	▪ Enjoyable	31	91,18
	▪ Unenjoyable	3	8,82
b. The attractiveness of learning	▪ Attractive	33	97,06
	▪ Not attractive	1	2,94
c. Subject matter	▪ Easy to learn	29	85,29
	▪ Difficult to learn	5	14,71
d. Assignment	▪ Challenging	29	85,29
	▪ Unchallenging	3	14,71
e. Assessment	▪ Overt	33	97,06
	▪ Not overt	1	2,94

The students' responses to the implementation of QBIM based on Table 6 were positive. The students stated that they enjoyed learning biology (91.18%), that the learning was considered attractive (97.06%), that the module was easy to learn (85.29%), that the tasks were challenging (85.29%), and that the assessment was good (97.06).

Discussion

The implementation of QBIM was shown to be effective in improving the junior high school students' biological knowledge and science process skills. The results of this research revealed that the EI of the biological knowledge mastery and the science process skills had percentages higher than the standards set for the study. QBIM can encourage active, minds-on and hands-on learning. Carin (1993:39) describes that the best way for students to learn science is through an active minds-on/hands-on approach that involves them in observing, measuring, predicting, inferring, investigating, and explaining the world in ways that parallel the methods of scientists. In the inquiry-based learning, students become engaged in many of the activities and thinking processes that scientists use to produce new knowledge (Abdi, 2014). QBIM made the students get involved in the learning process and enabled them to obtain experience to directly find the knowledge. Encouraging an experiential understanding of scientific concepts allows students to deepen understanding and makes the content more memorable and meaningful to them (Sutman et al., 2008:xi). Harrison (2014) states that inquiry provides both the impetus and experience that help students acquire problem solving and lifelong learning skills. The importance of direct learning experience has been advanced by John Dewey as learning by doing. The experience contributes to what we learn. Magnesen (1983) describes that the studies in memory retention indicate that persons

retain 10% of what they read, 20% of what they heard, 30% of what they saw, 50% of what they saw and heard, 70% of what they said, and 90% of what they said and did.

In addition, the use of QBIM in the science teaching and learning could provide opportunities for the students to practice the science process skills and engage them in the discovery of the biological knowledge through the deployment of the science process skills. This finding is in line with Sutman et al. (2008:15) who describe discovery as both the process of gaining scientific knowledge and skills and the culmination of what is learned. In this research, the students discovered the importance of joint, the characteristics of muscle contraction, the structure of human skeleton, the process of mechanical and chemical digestion, the foods that contain starch and fat, and the fruits that contain vitamin C.

The findings from the questionnaire demonstrated students' positive responses to the QBIM-based biology instruction in which 91.18% of them admitted being delighted to learn and 97.06% of them stated that teaching and learning was attractive. These data show that students are motivated to learn, and this is rightly in accordance with Suduc et al.'s (2015) finding that inquiry-based learning proved to be stimulating for students' motivation to learn, application of research skills, construction of meaning, and acquisition of scientific knowledge. Motivation is key to learning that determines students' learning activity. Psychologists define motivation as a process within an active individual, encouraging, giving directions, and maintaining behavior at all times (Slavin, 1994:345). Motivation is very important because it can encourage students to learn and perform learning activities. Inquiry-based instruction can provide students more challenging and meaningful tasks to engage in their learning and increase significantly their motivation (Tuan, et al., 2005).

The science learning by using QBIM actively involved the students to find out the answers to the questions. Questions in the module served as a guide for the students to think of finding answers through inquiry. Fun and interesting learning is the hallmark of an effective teaching and learning; and the state of being fun will allow someone to utilize all his/her potential optimally, can encourage his/her to learn well, and to become engaged and enthusiastic in doing something. An environment free from the threat of acquisition can provide a good learning and retention (Barba: 1998). Cotton (2012) describes that teacher questions act as instructional cues or stimuli that convey to students the content elements to be learned and directions for what they are to do and how they are to do it. Accordingly, the role of questions in teaching and learning is to promote to students the content to be learned and provide direction for what to do and how to learn.

In learning to use QBIM, every activity began with questions. Through questions, the teacher stimulated, guided, and assessed the science process skills and mastery of biological knowledge of the students. Each student was not only given the content of the subject (to know what), but s/he also had to use a number of science process skills (to know how). Science process skills have been called lifelong learning skills, as they can be used for daily living and for learning (Carin, 1993:8). Inquiring about nature is one activity that is used as a base by scientists to work or conduct an investigation and find out the concepts and principles of science that are studied by students. Asking questions is a very

important technique that can be used by teachers, and this technique can be utilized in a variety of learning objectives. Callahan et al. (1992) describe the existing 20 purposes why teachers use questions, namely: 1) to give the instruction, 2) to discover something unknown by the teacher, 3) to determine whether the students know something, 4) to develop students' thinking skills, 5) to motivate students to learn, 6) to provide training and practice, 7) to help students organize the material, 8) to help students interpret the material, 9) to emphasize the things that are important, 10) to show the relationship such as causality, 11) to know the interests of students, 12) to develop an appreciation to students, 13) to provide an assessment, 14) to give practical expression, 15) to reveal mental processes, 16) to indicate approval and disapproval, 17) to report, 18) to diagnose, 19) to evaluate, and 20) to get attention. Inquiry is often defined as a search for truth, information or knowledge, and the searching efforts are made through questions. The question is at the core of inquiry-based learning. Questions can lead to an investigation in an effort by students to understand the material being studied.

In the teaching and learning by using QBIM, the students were more actively involved in constructing knowledge rather than consuming knowledge. Therefore, learning became more meaningful, and content learned had a longer retention.

Conclusion

Question-based Inquiry Module (QBIM) was an effective medium for teaching biological knowledge and science process skills. The findings of this study also pointed out the students' positive responses to the QBIM-based science learning.

Disclosure statement

No potential conflict of interest was reported by the authors.

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References

Abdi, A. (2014) The Effect of Inquiry-based Learning Method on Students' Academic Achievement in Science Course. *Universal Journal of Educational Research, 2*(1), 37-41.

Barba, R.H. (1998) Science in The Multicultural Classroom: A Guide to Teaching and Learning. Boston: Allyn and Bacon.

Bell, R.L., Smentana, L. and Binns, I. (2005) Simplifying Inquiry Instruction. The Science Teacher. 30-31.

Callahan, J.F., Clark, L.H. & Kellough, R.D. (1992) Teaching in the Middle and Secondary Schools. United State of America: Macmillan.

Carin, A. A. (1993) Teaching Modern Science. New York: Maxwell Macmillan International.

Cotton, K. (2012) Classroom Question. Available at http:// -69.20.125.200-workshop, accessed 17 Mart 2012.

Chu, S.K.W., Tse, S.K. & Chow, K. (2011) Using Collaborative Teaching and Inquiry Project-based Learning to Help Primary School Students Develop Information Literacy and Information Skills. *Library & Information Science Research, 33* (2011), 132–143.

Dostal, J. (2015) The Definition of the Term "Inquiry-based instruction" . International Journal of Instruction, 8 (2):69-82.

Geoffrey R., S. (2010) A Module-Based Environmental Science Course for Teaching Ecology to Non-Majors. *Bioscene: Journal of College Biology Teaching, 36* (1), 43-51.

Goldman, S.R., Radinsky, J. & Wink, D. 2010. Learning as Inquiry. International Encyclopedia of Education, pp 297-302.

Harrison, C. (2014) Assessment of Inquiry Skills in the SAILS Project. *Science Education International, 25* (1), 112-122.

Haynes-Berry, M. & Berry, G. (2014) "Reading an object": Developing Effective Scientific Inquiry Using Student Questions. *European Journal of Science and Mathematics Education, 2*(2), 87-97.

Kuhlthau, C.C, Maniotes, L.K. & Caspari, A.K. (2007) Guided Inquiry: Learning in the 21st Century. Westport, Connecticut: Libraries.

Magnesen, V.A. (1983) A Review of Findings from Learning and Memory. Innovation Abstracts, 5(24) September 16 1983.

Martin, R., Sexton, C. Franklin, T. & Gerlovich J. (2005) Teaching Science for All Children: An Inquiry Approach. Boston: Allyn and Bacon.

Molenda, M. (2003) In Search of Elusive ADDIE Model. *Performance Improvement , 42* (5), 34-36.

Molenda, M. (2003) The ADDIE Model. Indiana University.

Morrison, G.R., Ross, S.M., Kemp, J.E. and Kalman, H.K. 2007. Designing Effective Instruction. New York: John Wiley & Sons.

Slavin, R.E. (1994) Educational Psychology: Theory and Practice. Boston: Allyn and Bacon.

Spronken-Smith, R & Walker , R. (2010) Can Inquiry-based Learning Strengthen The links between Teaching and Disciplinary Research?. *Studies in Higher Education, 35* (6), 723-740.

Suduc, A., Bizoi, M. & Gorghiu, G. (2015) Inquiry Based Science Learning in Primary Education. *Procedia-Social and Behavioral Sciences, 205*(63), 474-479.

Sutman, F.X, Schmuckler, J.S., & D. Woodfield, J.D. (2008) The Science Quest Using Inquiry/Discovery to Enhance Student Learning, Grades 7–12. San Francisco, John Wiley & Sons.

Thompson, T. (2017) Teaching Creativity Through Inquiry Science. *Gifted Child Today, 40*(1), 29-42.

Tofade, T.; Elsner, J., & Haines, S.T. (2013) Best Practice Strategies for Effective Use of Questions as a Teaching Tool. *American Journal of Pharmaceutical Education , 77* (7), Article 155.

Tuan, H.L., Chin, C.C., Tsai, C.C. & Cheng, S.F. (2005) Investigating The Effectiveness of Inquiry Instruction on The Motivation of Different Learning Styles Students. *International Journal of Science and Mathematics Education, 3*, 541–566.

Woolfolk, A. 2011. Educational Psychology: Active Learning Edition. Boston: Pearson.

Wu, J. W., Tseng, J. C. R., & Hwang, G. J. (2015) Development of an Inquiry-Based Learning Support System Based on an Intelligent Knowledge Exploration Approach. *Educational Technology & Society, 18* (3), 282–300.