Science teaching for enlightenment: A holistic approach in developing a teacher's guide for best practices to teach at secondary level

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Abstract

The ultimate goal of teaching is to produce enlightened students. It is believed that this is possible provided that teachers approach teaching in a holistic manner that exercises the best practices. They however need to have some form of guidance to teach in this manner. The paper describes the development of a teachers guide to teaching-learning (TGTL) at upper secondary school level. It is based on a holistic conceptual framework of best practices derived from the literature and empirically. The paper is made up of three parts: the descriptions of (1) the basic concepts: of enlightenment, best practices and holistic approach, (2) the framework and a holistic model for best practices (HOBP), assessment through classroom activities and

refinement and (3) the construction of the TGTL based on findings in (2). This paper however does not include the assessment and evaluation of the effectiveness of TGTL.

Introduction

A **t**eacher's **g**uide for **t**eaching-**l**earning (TGTL) for science teaching at secondary level was developed. It was based on best practices and a holistic conceptual framework in teaching science for enlightenment. The paper is made up of three parts: description of (1) the basic concepts of enlightenment, best practices and holistic approach (2) the framework and a holistic model for best practices (HOBP) used to construct the guide, the assessment and refinement of the HOBP model through classroom activities and (3) the construction of the TGTL based on suggestions for best practices in science teaching gathered from Malaysian science teachers and students, The construction of TGTL takes into consideration the students' learning problems. The authors believe that the TGTL developed can help teachers translate knowledge and understanding of best practices into classroom teaching, particularly teaching of physics at the upper secondary level. It provides teachers with professional assistance to manage teaching and ensure satisfactory student's performance.

The Basic Concepts

The basic concepts used in this paper are enlightenment, best practices and holistic approach.

(i) Enlightenment

Literally enlightenment means *being illuminated by acquiring new wisdom or understanding*. Within the context of science learning enlightenment refers *to education that results in an understanding and the spread of knowledge* (Wordnet, 2005). An enlightened person is one who after experiencing learning has the determination and courage to use his/her intelligence to confidently and independently apply whatever concepts learnt in various related situations (Kant, 1974). Such students will be able to explore by themselves more science concepts, to apply and to

find meaning of their scientific activities whether inside or outside the classroom rather than having to rely on close guidance by the teacher (Wikipedia, 2005).

Based on such definition of enlightenment, it is clear that the outcome of such approach to science education is that the student is knowledgeable, finds meaning to the essence of the concepts taught, and subsequently is able to self direct his/her own learning and later spread the knowledge learnt.

(ii) Best Practices

Best practices are terms that refer to the adoption of certain practices found to be effective in teaching and learning and in turn promote students' engagement and participation in the teaching-learning process.

(iii) Holistic Approach

The basic meaning of holistic is derived from a Greek word "ηολοσ" meaning "whole" (Mulligan, 2007). The Macmillan English Dictionary defines holistic as "thinking about the whole of something, not just dealing with particular aspects". Thus, adopting a holistic approach means that students have to be regarded as whole individuals. This implicates that every aspect of the human nature need to be considered as these aspects are interrelated coherently with one another (Murray, 1993; Patel, 2003). The National Education Philosophy of Malaysia emphasizes the need to produce students that excel holistically in the physical, emotional, spiritual and intellectual aspects. This provides the underlying foundation for the teaching and learning framework.

Based on the descriptions of the basic concepts, the holistic approach for best practices is the approach that considers students as whole individuals where the factors contributing to their difficulties in accepting new knowledge are all considered as part of the teacher-learning process. Teachers always need to adopt and adapt different practices that meet the needs of these students and demands of the topic that they are going to teach. These practices are what we referred to as the best practices.

The Framework and Model

The Conceptual Framework

This section gives a description of the conceptual framework of the **ho**listic approach for **b**est **p**ractices model (HOBP Model). The framework gives us the guide for the study to be conducted. It focuses on the elements integrated for the construction of the model. The three elements are: teaching-learning (TL) issues, elements of the TL process that include the best practices and the teacher's guide (Figure 1). The best practices take into consideration four factors that affect teaching and learning as shown in Figure 1. They are: (i) the teaching-learning issues and problems; (ii) the two levels of teaching learning process: communication by the teacher and management of information by the student; (iii) the content and; (iv) the resource materials.

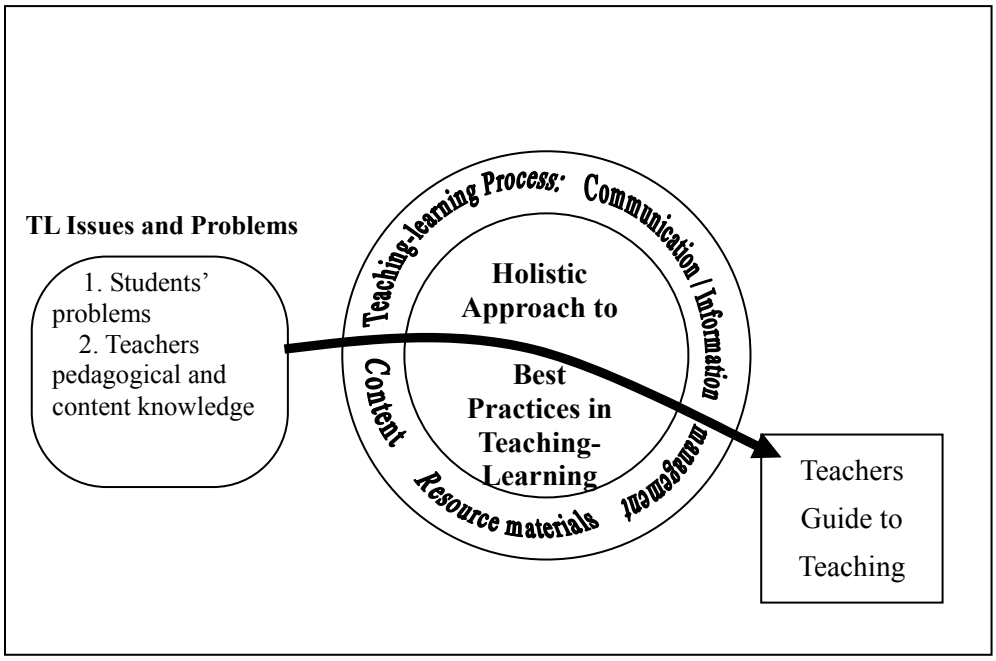

Figure 1 *Conceptual framework of the holistic approach to best practices in teaching-learning*

The conceptual framework for best teaching practices in teaching is summarized in Figure 1. This conceptual framework provides us with a working model (HOBP Model) for in the development of TGTL.

(i) Teaching Learning Issues and Problems

Teaching-learning problems and issues in this paper are with reference to the teachers'

and students' perspectives. The main issues for the teachers are their content knowledge and pedagogical content knowledge. For the students, preconceptions, psycho emotion and cognitive ability are issues that we believe contribute to learning.

Information on teaching-learning issues and problems were gathered from (1) teachers' interview (3 teachers) and survey (40 teachers); and (2) Malaysian students' misconceptions (Siti Hendon, 2003). Initially, an interview protocol was prepared based on the literature. Then each of the teachers was interviewed to find their general problems in teaching-learning and suggested solutions to the problems. Based on the findings of the interview, an open ended survey instrument was developed and a written survey was conducted to 40 in-service science teachers.

The main issue of teaching found is that teachers do not have enough time to spend on activities that can provoke their students' interest and understanding. Feedback from private interviews imply that teachers felt the most effective method for students to learn and apply a new concept is to engage them in hands-on, collaborative activities. However there is always a time constraint. The teachers also raised other problems like students' passive participation, and insufficient apparatus for lab activities.

(ii) Levels of Teaching Learning Process

The teaching learning process is actually a social activity. The student- teacher relationship is determined by the communication interaction between them. We need to realize that the actual teaching and learning process in the classroom occurs at two levels, (i) the communication of information by the teacher to the students and ii) the management of information by the students. The latter requires that students have the necessary internal cognitive mechanism in order to affect the actual process of learning. It is the authors' intention to approach the teaching learning process in a holistic manner. This therefore means that these two levels of teaching learning process have to be incorporated in the teaching model.

Communication of Information

In the teaching-learning process, communication plays an important role in the transfer of knowledge from the teacher to the students. The holistic approach considers teaching as a social activity. This means that it involves both the teacher and the students. It is therefore important that a two-way communication exists between the teacher and students in order to trigger learning. Communication in this paper

refers to teacher's behavior, good relationship between teacher and learners and communication styles. Studies have shown that these elements when considered can lead to effective teaching and learning (Beebe, 1994). Further direct communication between a teacher and students allows the teacher to get immediate feedback that can help the teacher gauge the students' understanding on what has been taught. This in turn can guide the teachers to refine the art of communication that helps students to the correct concepts of the topic being taught. With proper guidance, the teacher could bring the students to a higher learning development compared to the students' development without a teacher's guidance (Vygotsky, 1930).

Information Management

Information refers to sensation of messages which the mind concentrates upon (Kehoe, 1999).These messages have to be organized before it becomes knowledge for the individual. Due to the high level of abstraction in physics (Renner and Grant, 1978), knowledge is rarely developed spontaneously but requires instruction for its development. Only then can the students select the important information as the class is being held instead of concentrating on something that is not relevant to the lesson (Kehoe, 1999). Teachers using concrete models and analogies during instruction can do this, as these will help the students encode relevant information for better understanding.

(iii) Content

The content referred to in the HOBP Model is based on the Malaysian secondary school syllabus (Ministry of Education, 2004). This is to ensure that the content is parallel to the school physics syllabus. For the intended study the content is focused on the topic of light. The topics on light will cover the basic concepts and properties of light; light propagation, reflection and refraction. Since the HOBP Model is holistic, teachers are expected to integrate both their content knowledge of the topic with the pedagogy for teaching. This means that they should not only emphasize the content but to also make sure that their students achieve the in-depth understanding of the concepts that they are teaching. Only then can their teaching be expected to produce a lasting effect in the minds of their students, rather than students' forgetting what have been taught once the class is over.

(iv) Resource Materials

In this paper, resource materials refer to two supporting materials for interactive science teaching and learning (Hake, 1998); resources for (1) experimental work and (2) computer aided learning (CAL).

Experimental work

Experimental work is one factor that stimulates learning. Experimental work using inquiry, hands on approach stimulates natural curiosity. This will at the same time provides them with a solid conceptual framework needed to support the development of accurate concepts and achieve other learning objectives such as theory building (AGPA, 2005). Besides, by doing experiments students are usually spontaneously evoked to explain things that they experience. It is known that absence of experiential examples leads to shallow knowledge (or, in many cases, no knowledge at all, as such lessons is quickly forgotten). Therefore teachers need to provide experimental work that provides students with concrete examples that can facilitate their understanding of abstract concepts.

Computer aided learning (CAL)

The second aspect of teaching is the Computer Aided Learning (CAL). Nowadays, it has become a common practice in schools to use ICT as a medium of instruction. Computer Aided Learning (CAL) is a teaching approach that could promote learning. Students are provided with tools that aid their collection, manipulation, and analysis of information compared to the normal tasking and time consuming method of data collection and analysis. Next, the use of multimedia software ensures that students actively participate in the teaching learning process (Hake, 1998). Contrary to the one way passive learning process whereby students are the receiver of information and do not have any control to development or the content of the lesson, studying by multimedia could lead to active participation of the students. This in turn could lead to teacher's immediate assessment of the students' progress in the learning of subject matter during the lesson (Cox, 2002).

The Model

Figure 2 gives the model for holistic approach to best practices. There are three important elements in the model; the teacher, the student and the content. HOBP Model considers that both teacher and the students are participants of the teaching

learning process. The teacher characteristics are the content knowledge and the pedagogical knowledge while the student characteristics are preconceptions, cognition of information management and the psycho-emotional state of the students. It is communication that determines the effectiveness of the teaching learning process. This in turn is determined by the teaching approaches and the feedback between students and teachers. However there are two other factors that affect the teaching learning process. These are the content as prescribed by the syllabus and the resource materials.

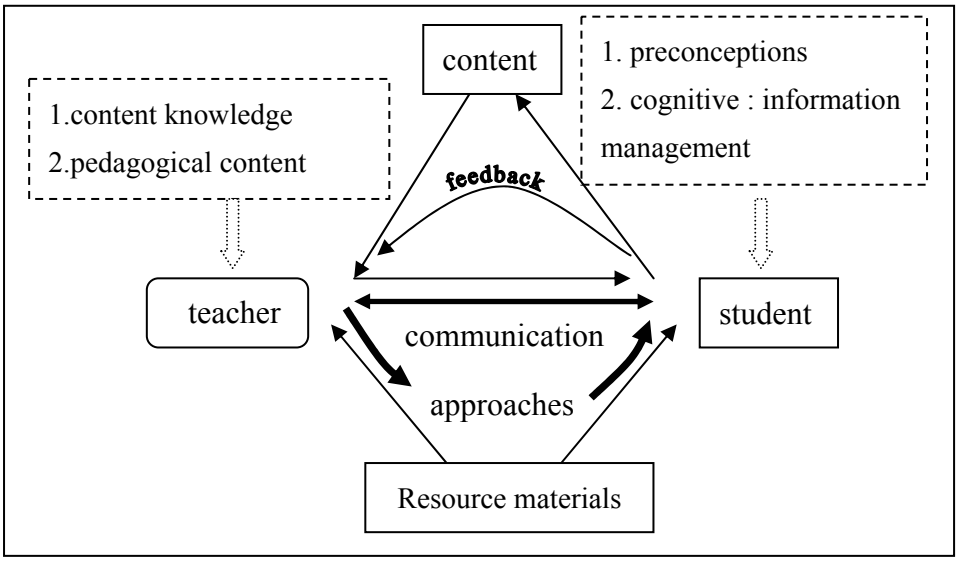

Figure 2. *HOBP model*

(i) Student Factor

We belief that three student's factors need to be considered for the development of a model and hence guide, holistically. They are the misconceptions, cognitive aspect and the psycho emotional aspect of the students.

Preconceptions

There are two kinds of misconceptions among school children. First is the misconception that occurs long before a concept is being taught. Osborne and Bell (1983) mentioned that students already have explanations for things that occur around them before any formal instruction. We could therefore expect five different outcomes in response to the new view supplied by the teacher. These

are: (1) the view is simply rejected, (2) the new view is misinterpreted to fit in with, or even support the student's present views, (3) the new view is accepted but in isolation from present ideas, (4) the new view is accepted but leads to confusion and, (5) the new view is accepted and forms a coherent view of the world. Secondly, there is also evidence that the way the topic is being taught can contribute to tenacious misconceptions (Taber, 2003). Therefore, it would be helpful for teachers to know their students' conceptions prior instruction so that teachers can adopt appropriate strategies during formal teaching. However the teaching approach that is finally adopted would depend on the teacher's awareness and understanding of their students' preconceptions. These preconceptions might differ from one student to another. Therefore, different teaching approaches are required for different topics that have recurring common misconceptions among the students.

Cognition

The cognitive goal of science education is to ensure that students understand the basic concepts and ideas found in the content of a given discipline. Students are also expected to develop cognitive and practical skills that enable them to apply whatever they have learnt to explain phenomena that happen around them and to solve problems. Unfortunately research findings have shown that such desired goals have not been achieved among a larger proportion of the student population. It is believed that this could be attributed to a teaching learning operation that is too examination oriented which influenced the school to work towards preparing students to pass examinations, often enough neglecting the higher objectives of education; the development of the cognitive critical thinking skills and the affective domain. Subsequently, institutions of higher learning that these students go to after completing their secondary education find them lacking in the cognitive and the higher order thinking skills required to self direct their learning and to manage the relevant information in their respective disciplines.

Psycho-emotion

The third element to be considered is the psycho-emotional aspect. The underlying assumption here is that the students' emotional states affect their readiness and acceptance to learn. Therefore knowledge cannot be forced onto a student if he himself is not ready to do so. It is the student's state of mind that will make him decide if he is going to learn what is being taught by the teacher that day. There are

factors that affect the psycho emotional state of the students hence their readiness to learn. These include the teacher student relationship, student-student relationship and approaches that can stimulate and satisfy the different needs of the students. When the teaching–learning activities are stimulating, satisfying and encourage students' participation, students are bound to be more interested in what they learn.

A holistic approach to teaching and learning process therefore means that these factors are being incorporated into the teaching and learning practices in the classroom. The challenge is how to ensure that this can be done successfully. Incorporating these three factors during teaching would hopefully revoke the apparently continued perception that physics learning is dry, difficult and dull. Actually when these three words are analyzed, it is found that each word refers to a different aspect of the teaching learning process. *Dry* can be associated with the way the subject matter has been presented, which many students felt were not related to everyday examples. *Difficult* refers to the student's perception regarding the meaning of what they are supposed to study or to learn. The terms used particularly the technical ones, are used in the discipline that students are not familiar with. They are not meaningful when presented to them so this affects their understanding and hence learning of the subject matter. *Dull* refers to the element of feeling. This is psycho emotional in tone and negative in nature. Thus to overcome the dry, difficult and dull nature of physics teaching and learning, the teachers need to look not just at the curriculum content of what is to be learnt by the students but also the method of the delivery of the subject matter. Undeniably this is related to the communication approach and style during the teaching learning process.

(ii) Teacher Factor

Content knowledge

A teacher himself is an important tool for teaching. Teachers should be well equipped with the content knowledge to be able to pass the knowledge effectively to their students. This is because students need their teachers' guidance to bring them to a higher learning development (Vygotsky, 1930). Therefore, teachers should be prepared with content knowledge to be able to facilitate their students into understanding the concepts and apply what they have learnt into real life situations and solve problems.

Pedagogical content knowledge (PCK)

Undeniably there are teachers who have been successful in teaching physics for students with different abilities. It would not be too presumptuous to assume that these teachers must have adopted teaching learning approaches that best meet the various cognitive and psycho-emotional needs of their students. Teachers' awareness of students' difficulties in the topic and students' different background could help teachers prepare lessons that can bring about optimum learning. They must also have communicated in a manner that promotes interest, understanding and effective learning. It would not be surprising that these teachers could have also used teaching learning tools that aid effective learning.

(iii) Teaching Approaches

Teachers have to make the necessary interventions if their students' misconceptions are to be corrected. Teachers need to provide their students with a range of experiences so that they are able to make amendments, refine or abandon their previous misconceptions in favor of the scientific understanding (Edgar, 2000). Therefore holistic best teaching practices would integrate several teaching approaches to teaching. These include inquiry, constructivism, ICT, cooperative and contextual learning. Though these approaches are different from one another they do not contradict but instead complement each other in the construction of knowledge by the students. These approaches are designed to bridge the gaps found along some particulars surrounding the concepts taught and should be communicated in a manner that promotes effective learning.

Contra to physics being dull, Williams et.al (2003) found that the two most predominant reasons that make students find physics interesting are the content and the practical nature of the subjects. Students find that certain topics are more interesting than others if they have relevance to them. For some students it is their perception of physics itself that results in the development of their negative attitude to the subject. This therefore means that best practices to physics teaching should include approaches that overcome the raised issues and problems

The best teaching practices that are based on a holistic approach to teaching will have to be multidimensional. This therefore means that the teaching and learning of science, in particular physics will not just focus on the content but also other factors that affect

learning. When teachers adopt a holistic approach to teaching and feel responsible in facilitating optimum learning, the end result of the teaching-learning process will be enlightened students. As teaching learning practices are multidimensional, they are bound to be complex in nature especially when students are found to have prior misconceptions.

Assessment of the HOBP

The HOBP was assessed in two stages in a for physics teaching, that is (i) determination of both the teachers' and students' perceptions of best practices in teaching and learning and (ii) classroom implementation. A Likert-style questionnaire on best practices on the teaching-learning of physics was developed based on the elements described in the HOBP model. The questionnaires were distributed to a sample of 200 Malaysian in-service physics teachers via postal method. A total of 112 forms were returned. A similar survey instrument was developed and adapted for the students. A total of 265 physics students responded to the survey.

The knowledge on best teaching practices was empirically determined in this study. Prior to developing the TGTL, the best practices for effective teaching among Malaysian physics educators were compiled. Teachers also provided input regarding their teaching problems, constraints and practices. This information was then matched against students' perceptions on how physics should be taught and learnt. The findings of the survey reinforced the structure of the HOBP model which was used to develop the TGTL.

Construction of the TGTL Based on Findings

Based on the analysis of the surveys, a teachers' guide to the teaching-learning (TGTL) was then developed. The HOBP Model was used to develop the TGTL. This TGTL provides suggestions on suitable teaching practices that can assist teachers to integrate the knowledge content with the pedagogy for teaching. By using this guide, teachers will not only be prepared with content knowledge but are better equipped with tools that can help them improve their pedagogical content knowledge and skills to handle and manage their students' learning.

It is to be noted that this model consists of empirically determined appropriate teaching practices. As such any physics teacher can adopt them in the course of their teaching activities. For this paper, the teaching practices are confined to the teaching of Light. This is because one of the authors had already conducted a study on Malaysian secondary students' misconceptions of light (Siti Hendon, 2003). It is therefore appropriate that the next step be taken is to help teachers address these problems of misconception.

Preparation of TGTL for Classroom Implementation

The second stage of assessment of the TGTL was through classroom implementation. The TGTL was implemented in the classroom as one of the authors' post-graduate research activities. The teacher was first briefed on the TGTL and was requested to prepare and conduct the lesson using the given guidelines. Based on the survey findings, a Light Activity Kit and a Student's Manual were also developed to assist teachers and students in the TL of Geometrical Optics. Teaching practices selected were aimed at helping students avoid developing the common misconceptions, enhance their interest in learning, thus resulting in students becoming more enlightened.

This TL process was then assessed through classroom observation, interviews and written test, and surveys for the students at the end of the lesson. The objectives of the assessments were (1) to observe the teachers' adaptation to the TGTL; (2) to determine the students' responsiveness to lessons taught using the TGTL; (3) to determine the extent TGTL could lead to students becoming enlightened and having the correct conceptions after the lessons and; (4) to get input from both the teacher and students regarding their views on the use of the TGTL lesson. Findings of the assessment will be published in another paper.

Conclusion

This paper has first discussed the holistic conceptual framework of best practices in teaching physics. Based on this framework a HOBP model was then developed. The unique feature of this model is that it integrates the factors that affect best practices in the teaching and learning of light. These are communication, information management, content and infrastructure. In particular, it places the learners at the centre of the

learning process and emphasizes on active learning. The HOBP Model was then assessed and refined through surveys on physics teachers and students on their conceptions of Best Practices.

The second part of the paper describes the TGTL, how it was to be implemented and refined. It was assessed through classroom observation, interviews, written test and surveys for the students. The objective of the assessment was to find out the suitability of the TGTL for both teacher and students, whether it was successful in enhancing learning. The TGTL developed was expected to be applicable and adjustable for the teaching of other concepts in physics.

References

Akron Global Polymer Academy, AGPA (2005). *Best teaching practices* (online) http://agpa.uakron.edu/K12/index.html 12 Sept 2005.

Bebee, S.A., & Ivy, D.K. (1994). *Explaining student learning: An emotion model*. Paper at the Annual Meeting if the Speech Communication Association (80th, New Orleans, LA, November 19-22, 1994)

Cox, A. & Junkin, W.F. (2002). Enhance students learning in introductory physics laboratory. *Physics Education, 37*(1), 37-44.

Edgar W. J. (2000). What physics teachers can learn from research in physics education. *Physics Education*, *35*(4), 245-249.

Hake, R.R., (1998). Interactive-Engagement vs. Traditional Methods: A Six-Thousand- Student Survey of Mechanics Test Data For Introductory Physics Courses. *American Journal of Physics* (66): 64 (online) http://www.physics.indiana.edu/~sdi/ajpv3i.pdf

Kant, I. (1974). An Answer to the Question: *What-is-Enlightenment?* (online) http://eserver.org/philosophy/kant/what-is-enlightenment.txt 12 Sept 2005.

Kehoe Colleen (1999) The Information Processing Theory. [online] http://chd.gse.gmu.edu/immersion/knowledgebase/strategies/cognitivism/informationprocessing.htm, 7 Nov 2005.

Ministry of Education. (2004). *Integrated Curriculum for Secondary Schools. Curriculum Specifications Physics Form 4*. Kuala Lumpur: Curriculum Development Centre.

Mulligan, E. (2007). *The meaning of 'holistic'*. (online) http://www.superstar.org.uk/massage/Holistic.html). 9 June 2007.

Murray, J.I. (1993). A holistic, collaborative approach to teaching assessment and instructional development. Paper presented at the Annual International Meeting of the National

Institute for Staff and Organizational Development on Teaching Excellence and Conference of Administrators (15th Austin, TX, May 23-29, 1993) (also online) http://www.eric.ed.gov/ERICDocs/data/ericdocs2/content_storage_01/0000000b/80/25/65/7a.pdf

Osborne,R.J,, Bell,B.F.(1983). Science Teaching and Students Views of the World. *Europeon Journal of Science Education, 5*(1), 1-14.

Patel, N.V. (2003). A holistic approach to learning and teaching interaction: Factors in the development of critical learners. *The International Journal of Educational Management*, *17*(6/7), 272-284.

Renner, J. W. & Grant, R. W. (1978). Can student grasp physics concept? *The Science Teacher*, *45*(7), 30-33.

Siti Hendon S.A (2003). *The understanding of light and its properties among secondary school students*. Unpublished Master's project paper.

Taber, K. (2003). Responding to alternative conceptions in the classroom. *Physics Education*, *84*, 99-108.

Vygotsky, L. S. (1930). *Mind on Society*. Transcribed by: Andy Blunden and Nate Schmolze Cambridge, MA : Havard University Press.

Williams, C, Stanisstreet, M. , Spall, K. , Boyes, E. & Dickson, D. (2003). *Why aren't secondary students interested in physics? Physics Education, 38(4), 324-329.*

Wikipedia. (2005). Enlightenment (concept). [online] http://en.wikipedia.org/wiki/Enlightenment (26 Oct 2005)

Wordnet. (2005). Enlightenment [online] http://wordnet.princeton.edu/perl/webwn?s=enlightenment (26 Oct 2005)