0. Introduction

This resource, currently about 300 pages online, contains a summary of the required theory (plus a few additions marked with *-signs) for the Higher Level Physics in the IB. A number of calculation problems are given for some of the chapters, and these are developed and their number increased continuously. All rights to the Compendium are reserved by the author and Vasa övningsskola (Vasa Teacher Training School/ Åbo Akademi University, Finland) but it is free for anyone to use for non-commercial purposes such as teaching the IB programme, including the production and further spreading of locally edited versions.

Some advantages of an electronic compendium are:

- it never runs out of print
- the individual teacher can edit it before printing, to change the order of the sections, add own material etc.
- digital photos of the lab equipment used in your school can be inserted
- it can be constantly developed: every year the individual teacher can make new changes to the text, graphs or other
- when a major curriculum change occurs, more extensive revisions will be needed but all of the old version need not be thrown away
- prospective students in pre-IB-classes and/or junior high schools or middle schools can familiarize themselves with it or use parts of it
- after graduating from the IB, the student can have always have the IBPC near if reviews are needed

The files are made with MS Word 2000 and their combined size is less than 5 MB so they can easily be transported on a USB memory stick. The sketches and graphs in the Compendium are (hastily!) drawn by hand and scanned as .jpg-files. If someone wants to improve them a quick method is to zoom in or out the screen so that 1 cm on the monitor precisely matches 1 cm on the paper printout and then fit hand-drawn sketches on paper (e.g. "Post-It"-pieces) onto the monitor, take a printout and attach or tape them onto it - and then off to the photocopier! It looks silly but works fine. The graph files are coded with x (measurement), m (mechanics), t (thermal physics), w (waves), e (electricity and magnetism), a (atomic, nuclear and quantum physics), r (relativity), s (astrophysics) o (Optics) or h (Historical physics). There is also a section about Mathematical physics focusing on the applications of calculus in physics and some material relevant to the internally assessed IB investigations. A chapter about the connections between physics and Theory of Knowledge is under development.

Comments and other contributions to future improved versions of the IB Physics Compendium can be sent to

Thomas Illman

tillman@abo.fi

Below is a short article explaining the pedagogical ideas behind the IB Physics Compendium

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The IB Physics Compendium - a tool for non-constructivist education

Thomas Illman, Vasa Teacher Training School, Finland
tillman@abo.fi

1. Introduction

This article presents two common aspects of "constructivism" in science education, and some of the criticism of them: the anti-realist or ambiguous philosophical stances of many versions of constructivism; and the emphasis on practical experimental work in the classroom. An alternative to this, a non-constructivist perspective based on an explicitly realist philosophy and an Ausubelian theory of teaching and learning is then suggested. Finally, a brief presentation of the IB Physics Compendium, an electronic textbook as a tool for this type of teaching is included.

2. Philosophical constructivism

The ancient Greek philosopher Gorgias is famous for three claims, two of which are that nothing exists, and that if something existed, it is unknowable. Since that time, the position that there is no ultimate physical reality has been argued by many and questioned by others. A recent defense of a modest realist position from the point of view of the practising physicist rather than that of the academic philosopher is given by Alan Sokal and Jean Bricmont [1]. Their critique of antirealism is summarised with a Bertrand Russell quote as:

"The concept of 'truth' as something dependent upon facts largely outside human control has been one of the ways in which philosophy hitherto has inculcated the necessary element of humility. When this check upon pride is removed, a further step is taken on the road towards a certain kind of madness - the intoxication of power which invaded philosophy with Fichte, and to which modern men, whether philosophers or not, are prone. I am persuaded that this intoxication is the greatest danger of our time, and that any philosophy which, however unintentionally, contributes to it is increasing the danger of vast social disaster." [2]

A similar philosophical trend has been noted in science education, in the form of "radical or "social" constructivism [3]. A common problem in analysing theories of knowledge is that they are often formulated in an ambiguous way, so that different interpretations can be used depending on whether or not an informed critic is present. For a short presentation of the difficulties in defining what, if anything, philosophical constructivism means, see this author's earlier article [4].

3. Pedagogical constructivism

While the relations between the theories of knowledge and theories of teaching and learning are anything but uncomplicated, it is not impossible to discern that some degree of skepticism towards transmission of knowledge is common among anti-realist thinkers. Two statements of Gorgias were presented above; the third claim for which he is famous is that 'If anything can be known, knowledge of it is incommunicable'. And the quote of Bertrand Russell pertaining to the disastrous effects of philosophical relativism is taken from Russell's description of the philosophy of John Dewey, more known as an educator with a preference for "learning by doing".

In recent decades, physics education has been affected not only by anti-realist or at least non-realist philosophies but also by an emphasis on practical work for a variety of reasons:

"There is emphasis on doing science for a variety of reasons., e.g. pedagogical ('they will understand more if they have contact with the phenomena'), strategic ('you try keeping them occupied for a double on Friday afternoon'),
evaluative ('in our scheme we test what they can do regularly and that has made a lot of difference to their motivation'), blackmail ('Can't we do an experiment, Miss/Sir?) or even scientific ('We want them to experience doing real science') [5]

The idea of "doing real science" in the form of school experiments is especially questionable, since real science involves repeating and gradually refining a certain experiment many times over a longer period of time, while school experiments are rarely repeated week after week. This appears to indicate that their primary objective is to provide entertainment rather than education - one would not tell the same joke to the same audience repeatedly either! For a more systematic criticism of this experimental approach, see the work of Hodson [6],[7].

4. Ausubel and meaningful reception learning: pouring water or playing Tetris?

Although some development has taken place in this field since the 1960s and the importance of the theoretical framework and preconceptions of the students has received more attention, the focus on student-driven inquiry rather than transmission of knowledge persists [8]. For those who like Austin [9] maintain that while student investigations are valuable, 'there are some things that students can only learn by direct transmission: from the teacher, from a book or from another similar source', an alternative approach to science teaching is needed.

This alternative emphasis on the importance of knowledge transmission does not, however, necessarily mean that the importance of the student's preconceptions need be downplayed in a behaviourist way. David P. Ausubel, who brought the student's preconceptions into the focus of educational theory, distinguished between two dimensions of teaching and learning: that of rote vs. meaningful learning (whether or not the new knowledge is anchored in earlier notions) and reception vs. discovery learning. Ausubel recommended meaningful reception learning, not discovery learning, as the primary method of transmitting subject matter knowledge. [10].

Instead of picturing knowledge transmission as a process of 'pouring' knowledge into the students like water into empty vessels, meaningful reception learning gives the teacher a role similar to that of a Tetris (a computer game where shaped blocks fall into a pit where you must arrange them so they fit neatly) player who must take into account both the structure of the pieces to be dropped (the subject matter knowledge) and that of the pieces already in place (the student's preconceptions). Another possible metaphor is that of the bridge: teaching is about building one between the two equally important bridgeheads of subject content and student preconceptions rather than focusing narrowly on either of them. In the 1960s when Ausubel's theory was presented behaviourist educationists were forgetting the student - today, constructivists are forgetting the knowledge that needs to be transmitted and received.

Developing knowledge transmission: The open-source electronic text

There is little the individual teacher can do to make educationists, politicians or school administrators question the overemphasis on experiments in science teaching. But what he or she can get involved in is development of the "traditional" knowledge transmission which in most school systems still can be used for much of the allocated teaching time. The primary tool for this work is the physics textbook. In the realist philosophy of Karl Popper the possibility of a world of theories which though not material has a partial autonomy and can be incorporated into books [11] or other similar vehicles is suggested. Today more and more information is stored and communicated in an electronic form and this trend may be perceived by some as one more aspect of modern, "constructivist", education.
But this author will argue that ICT in physics education may instead turn out to be a powerful tool for a transmissionist pedagogical conservatism, and attempts to demonstrate this in the form of the IB Physics Compendium [12], an electronic physics textbook which is available in a format that can be not only used but also freely edited by the teacher in several ways:

- When the curriculum is reformed, the old version of the text need not be totally discarded, but can be edited to fit the new syllabus, while retaining large portions of the earlier book.
- The teacher can develop the text continuously from year to year, making small changes where necessary.
- These changes may be inspired by the latest findings of educational science, but may just as well come from a textbook half a century old. In this way, pedagogical ideas will no longer be judged based on whether they are old or new, but on whether they are good or not.
- Instead of acquiring and starting to use the new experimental equipment depicted in the new textbook, the teacher may produce digital images of existing equipment and insert them into the text.

All this places more control over the teaching into the hands of the individual teacher rather than reformist educators. This online physics textbook conforms to the Higher Level Physics syllabus of the International Baccalaureate Organisation. Some additional material is included, in order to cover the contents of the national high-school physics programme in Finland. The files are published in the Microsoft Word-format and though all rights are reserved they are freely available for all non-commercial use.

References


