Search for standards in the design of students' science laboratory worksheets

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Abstract
Modern education theory has rejected the teacher centered instruction and has put the student in the center of the learning process. In the frame of this student-centered approach many scenarios have been developed for all the subjects of the curriculum, in Greece as well in the rest of the world, which commonly are accompanied by worksheets for the students. In the present work we search the different styles of the worksheets specifically for the science subjects, based on a set of worksheets accumulated at the educational portal of Greek Ministry of Education (e-yliko) with the purpose of determining if there is a repetition of style which could lead to standardization. The analysis shows that although different people have authored the above material repetition exists and thus allows the definition of a standard. The documentation of the standard could help both the teachers and the students and will greatly facilitate the educational process.

Introduction
The aim of science education is to help students develop an understanding of the natural world: what it contains, how it works, and how we can explain and predict its behavior (Bécu-Robinault, 2002; Berry et al., 1999). So, in teaching science, we build upon students' everyday knowledge of the world around them – and augment this by providing carefully designed activities in which students observe or interact with real objects and materials (Charney et al., 2007; Donnelly, 1998). These activities (labworks) are usually carried out in teaching laboratories or, in the case of some courses, in the field (Clough & Clark, 1994; Tiberghien & Osborne, 1995). The fundamental purpose of any labwork task is to help students to make links between two domains: the domain of real objects and observable things, and the domain of ideas (Hofstein & Lunetta, 2004). Through labwork, students also learn about the scientific approach to enquiry Lazarowitz & Tamir, 1994; Lunetta, 2007).
Despite many teachers' wishes, open-ended project work is rarely practiced (Kang & Wallace, 2005). The most frequent type of labwork tends to be in small groups of students working with real objects/materials following very precise instructions about methods and analysis given by a teacher or a written source (Millar, Tiberghien & Le Marechal, 2002; Mortensen & Smart, 2007), referred to as a 'labwork sheet' or *worksheet*. A worksheet**,** according to Wikipedia (http://en.wikipedia.org/wiki/Worksheet)**,** is a piece of paper, often preprinted in a way designed to help organize material for learning or clear understanding.
Teachers in Primary and Secondary Education usually have to use worksheets to support their teaching and the achievement of their teaching objectives (Olsen, 1993; Wickman, 2004). Such worksheets are included in the school books, in the lab books and in educational software's manuals. Teachers can – depending on their needs- use the ready worksheets or they may modify them or even create new.
It seems that there is not a standard to build a science laboratory worksheet. So In this work we analyzed a sample of worksheets looking for similarities that could give rise to establish such a standard. Finally, we discuss the pros and the cons of the use of standards in building worksheets in science education.

Methodology
In the present work we investigate if the existing worksheets have been created according to some model, if such a model exists and if there is, of what kind. We searched details as: in what degree the teaching objectives are presented, the existence of directives of use of equipment, and other characteristics.
As a lot of specialities of teachers use worksheets, we tried to limit the sample of research in science teachers in secondary education, because we are teachers in public high schools. Worksheets about this specialty exist: in the school books, in the lab books and in educational software manuals. We have limited the search in the worksheets that are contained in

educational software. There are 85 worksheets of this kind available on-line in the educational Portal of Greek Ministry of Education, named e-yliko, (www.e-yliko.gr). These have been published there during the last decade, from independent teachers of public education or from work teams in the frame of educational material creation.
After having scanned an adequate number of worksheets focused in school science, from different teachers and creators, we have spotted various characteristics that are usually appearing in the structure of worksheets. As for a next step, we categorized those characteristics appearing in the sample we examined. Our aim was to make out if some model existed followed by the writers, despite the fact they had no specific guidelines.

Results - Analysis
At first, we recorded the length of each worksheet, which means the number of pages per worksheet. The mean value of pages per worksheet is 2.97 pages, the median is 2 pages and finally the majority of the worksheets consist of only 2 pages (Figure 1)

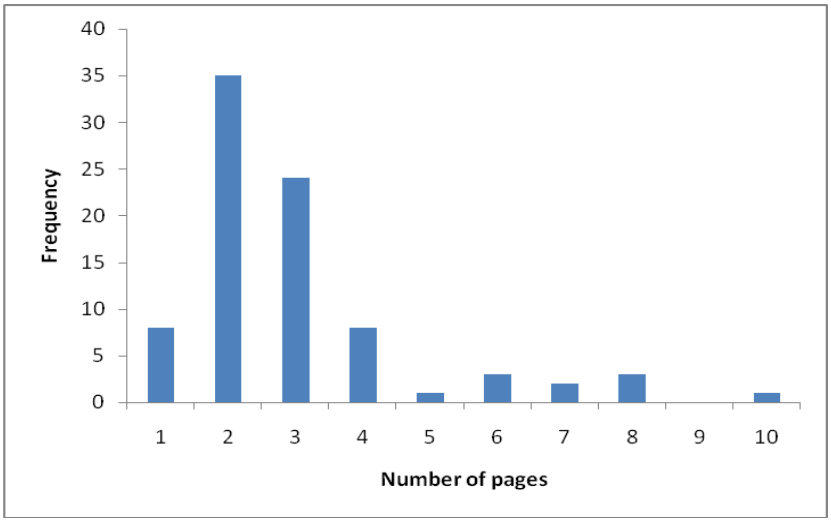

Figure 1. Number of pages per reviewed worksheet

The length of a worksheet is an important parameter on the way to establish a standard: it's affect the piece of information that can be provided to students. For example, a one page worksheet may not be able to support student's effort to master the teaching objectives. On the other hand, a ten pages worksheet could overload students.

Worksheets in colour
42 of 85 (49.4%) worksheets are in colour. Why is this important? In our opinion maybe a colour worksheet is more expensive to be reproduced but carry more information and could make easier the achievement of organize the teaching material in a way that is more attractive to students.

Worksheets including figures embedded
42 of 85 (49.4%) worksheets include figures embedded. These figures are screenshots of a simulation or figures relative to science topics to be instructed. Through these figures one can gives clear instructions on mastering educational software or to highlight the fundamental topics.

Teaching objectives given
On only 32 of 85 (37.6%) worksheets, the writer announces the teaching objectives. In our opinion this is bad: research on science didactics has point out that when a student is aware of what is expected to be able to do at the end of an instruction then he/she has positive attitude towards learning.

Demographic information

On 62 of 85 (72.9%) worksheets the student has to fill demographic information, such his/her name, the date, and the class. These information can be used from the instructor for student's assessment. The anonymity is usually used on research questionnaires.

Software to be used
On 58 of 85 (68,2%) worksheets the writer reports the software which is been used. So the student can just follow the instruction to conclude the workshop without having to ask for this or that spending his/her time and interrupting the educational procedure.

Simulations in use
On 59 of 85 (69.4%) worksheets are reported the filenames of the simulations used in workshop. As these simulations consist part of the teaching material holds what was said in previous transparency.

Required work time
Surprisingly, only on 1worksheet is reported the required work time! As we have already mentioned the student must know what he/she expected to do and in what time interval. So, we think that this is crucial information.

Concepts and quantities
Only 12 of 85 (14.1%) of worksheets named the concepts of physics studied. It's important for students to be aware of the concepts that considered to be known as far as the concepts that will be taught. This way they can make connections with what they already know and what they will learn.

Fundamental knowledge / definitions
On 15 of 85 (17.6%) worksheets there is an introduction with fundamental knowledge, definitions and basic formulas. This part is quite extended in some worksheets raising the total number of pages.

Basic operations of the simulation (guidelines)
On 57 of 85 (67%) worksheets are given clear guidelines to students for mastering the simulation. A few writers believe that the students have to play with the simulation in order to understand how it operates as a part of the educational activity. So they don't provide guidelines to students.

Steps
Finally, all (100%) the worksheets have successive steps that guide students to conclude their work. The steps are like these: at first do this, what you see? Can you prevent what will happen? Run the simulation. Record what happen. Precede the data, and so on. It's obvious that this is the heart of any worksheet and it fills the greatest part of it. In our analysis we have not deal at all with the structure of these steps as this strictly depends on method of instruction.

Discussion
From data above it's obvious a clear diversity of views on how a science worksheet has to be built. Only a few characteristics of those that have been examined appear in most worksheets. Others characteristics, despite the conclusions of research in science didactics appear only in few worksheets. That means that the worksheets are differentiated as for the target group, as for the teaching approach, but also as for their format. Its worth to mention that even the same creator builds worksheets with different format when he/she introduce different topics.
So our investigation does not elevate a standard for building a science laboratory worksheet.
As the research was limited in the format, it is useful to see the pros and the cons of the use of standards in science worksheets as for the format:
The advantages:

- It's easy for the teacher who for the first time has to create a worksheet (or that has to modify one already existing) to know how precisely he/she has to form it (as for the format).

- It's easier for the students to work with uniform worksheets. This will facilitate their comprehension and will accelerate (or at least will not slow down) the process of learning.
- A generator of worksheets could be created, based on a specific standard and published for common use in the portal of the Ministry of Education.

Worksheets generators, in English are already available in the internet (Figure 2), but they also do not follow the same model.

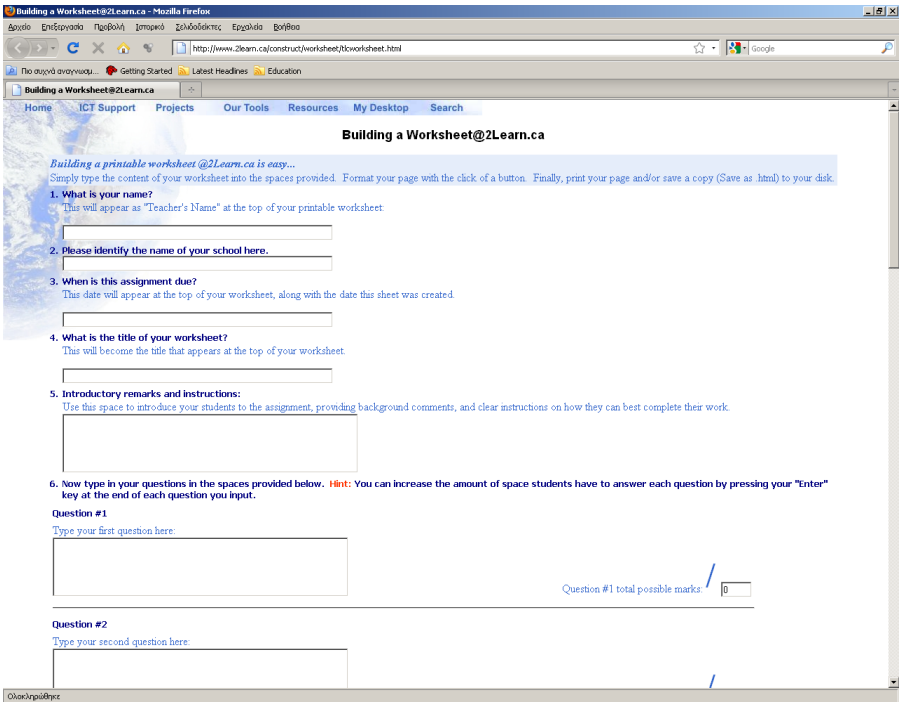

Figure 2. A worksheet generator available on internet (http://www.2learn.ca/construct/worksheet/tlcworksheet.html)

The disadvantages:

- Every teacher, as author/creator of educational material, may need his own form of worksheets, which will serve his own needs and his own teaching objectives.
- Many instructive objects exist in the curriculum, with differentiated needs as for the worksheets
- The format of worksheets may have to be different for various ages of students for pedagogical reasons.

Conclusions

Η εργαστηριακή δραστηριότητα αποτελεί αναπόσπαστο μέρος της διδασκαλίας της Φυσικής. Ενδεχομένως για μεγάλης ηλικίας μαθητές να μπορούσε να υποστηριχθεί η ανοικτού τύπου εργαστηριακή δραστηριότητα αλλά για τους μαθητές της δευτεροβάθμιας εκπαίδευσης η χρήση φύλλων εργασίας είναι μάλλον αναγκαία, τουλάχιστον μέχρι ενός βαθμού.

Για διάφορους λόγους, που συζητήθηκαν παραπάνω, δεν υπάρχει κάποιο πρότυπο σύνταξης των φύλλων εργασίας. Μπορεί άραγε κάτι τέτοιο να γίνει; Θα βοηθούσε να μεγιστοποιηθούν τα μαθησιακά οφέλη της εργαστηριακής δραστηριότητας ή θα περιόριζαν την αυτενέργεια των μαθητών και την ικανότητά τους να σχεδιάζουν και να πραγματοποιούν δραστηριότητες. Θα διευκολύνονταν οι εκπαιδευτικοί στη σύνταξή τους ή θα θεωρούσαν ότι εγκλωβίζονται από την τυποποιημένη διαδικασία;

So the issue of developing a standard for building worksheets in science education remains open for further investigation. Undoubtedly, a lot of job has to be done in this direction before the establishment of a standard in this field.

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