Gender Differences In Freshmen's Physics Related Affective Characteristics

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Abstract

Purpose of this study is to find out gender differences in freshmen's selected affective characteristics related to physics, and to determine the best-fitting structural equation models for males' and females' physics related affective characteristics. The researchers developed the Affective Characteristics Scale, which consisted of 53 items related to 11 selected affective characteristics. Sample of the study consisted of 433 female and 435 male students in three public universities in Ankara. A one-way multivariate analysis of variance (MANOVA) was conducted to determine the effect of gender on freshmen's physics related affective characteristics. Significant differences were found among gender groups on the dependent measures in favor of male students. Two different models derived from the literature were tested for male and female freshmen. While the unidimensional model exhibited best fit for females, a multidimensional model different from the proposed model exhibited best fit for males.

Introduction

There are many studies related to gender differences in students' science related affective characteristics in science education literature (Jones, Howe, & Rua, 2000; Martin et al, 2000). However, there are few studies related to students' physics related affective characteristics (Häussler, 1987). Osborne, Simon and Collins (2003) reviewed research related to students' attitudes towards science and stated gender as the most significant factor related to students' attitudes towards science. Jones, et al (2000), Dawson (2000) and Häussler (1987) found that boys are mostly interested in physical topics, while girls prefer biological sciences. Martin et al (2000) reported gender differences in students' physics related affective characteristics in favor of boys. Correspondingly, Weinburgh (1995) found that boys show a more positive attitude toward science than girls in each of science subject areas.

Several studies were conducted to explore the causal nature of the relationship between achievement and related affective factors (Mattern & Schau, 2002; Rennie & Punch, 1991; Schibeci & Riley, 1986; Willson, Ackerman & Malave, 2000). Only Mattern and Schau (2002) compared males' (N=233) and females' (N=205) models of the relationship between science attitude and science achievement. No cross effects model, which proposed science achievement-1 influenced only science achievement-2, and attitudes toward science-1 influenced only attitudes toward science-2, exhibited the best fit for girls and no attitudes-path model, which proposed science achievement at time-1 influenced attitudes toward science-2 and science achievement-2, and attitudes toward science-1 influenced only science achievement-2, exhibited the best fit for boys.

Purpose of this study is to find out gender differences in freshmen's selected affective characteristics related to physics (AFFECT), and to determine the best-fitting structural equation models for males' and females' physics related affective characteristics. In the literature some studies define attitude in a broader sense and use it instead of affect. The affective characteristics selected for this study are: interest in physics courses in general (INTPC), interest in the freshmen physics course (INTFC), importance of the physics courses in general (IMPPC), importance of the freshmen physics course (IMPFC), aspiring extra activities related to physics (ASPEXT), student motivation in physics (SMOT), achievement motivation in physics (ACHMOT), physics test anxiety (PTANX), physics course anxiety (PCANX), physics self-concept (PSCON) and physics self-efficacy (PSEFF). The affective variables used in this study were selected from the most commonly studied variables in the science and mathematics education literature.

Proposed Models

There are two different approaches constructing the affective characteristics questionnaires in the literature (Gungor, Eryilmaz & Fakioglu, 2006). Some of the researchers constructed scales with sub-scales such as anxiety, enjoyment, interest, motivation, and self-confidence (Aiken, 1979; Gogolin & Swartz, 1992; Schibeci & Riley, 1986). The model representing the structure of these scales is named as the unidimensional model and presented in Figure 1. Some other researchers have defined attitudinal variables (Fraser, 1981) and motivational variables (Kremer & Walberg, 1981; Uguroglu & Walberg, 1979) independently. This model was named as the multidimensional model and presented in Figure 2.

Figure 1: Unidimensional model for the AFFECT

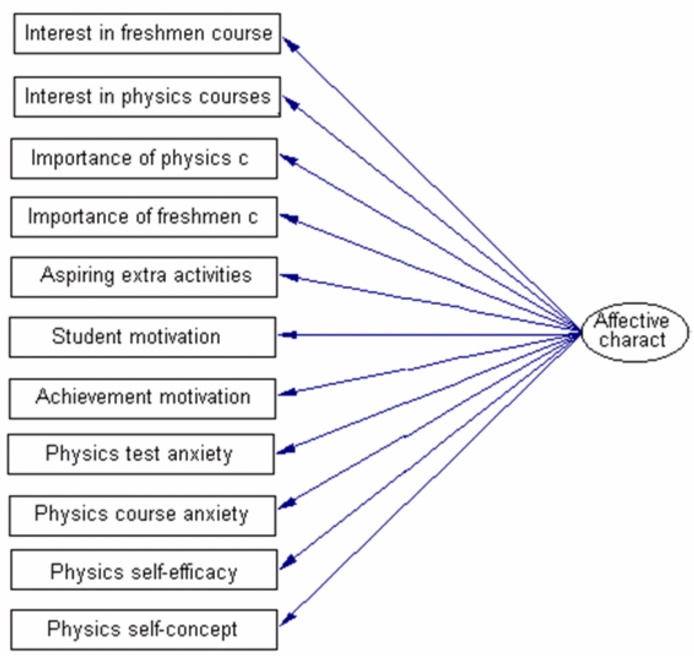
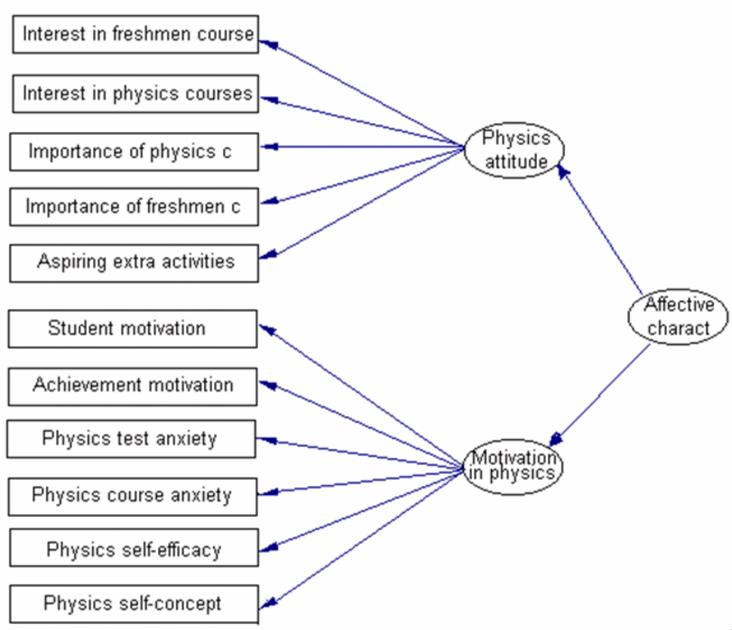


Figure 2: Multidimensional model for the AFFECT



Methodology

Sample

Sample of the study consisted of 433 female and 435 male freshmen in three public universities in Ankara. Data were collected in the spring semester of the 2001-2002 academic year. Convenient sampling was used. All the students were registered to the same freshmen physics course related to the electricity. This course was a compulsory course for all of the students' programs.

Measuring Tools

Results of the examinations in this physics course were used as the students' physics achievement scores. The researchers used the Affective Characteristics Scale, which consisted of 53 items related to 11 selected affective characteristics. This scale was developed as part of a master's thesis by the researchers (Abak, 2003). The items were scored on a 5-point Likert scale: 1 being (strongly disagree), 5 (strongly agree), and 3 being the neutral point. Negatively worded items were reversely scored. Alpha reliability coefficients of the sub-scales were ranging from .84 to .92.

Procedure

Social Science Citation Index and the Ebscohost (including ERIC) were searched for the literature review about the gender differences. The Affective Characteristics Scale was developed by the researchers (Abak, 2003). The scales were delivered to the data collectors by the researchers. Physics instructors, research assistants and the first author of the study were the data collectors. All the data collectors were informed before the administration. Moreover, a direction explaining the purpose of the study was written for the students above the items, in the questionnaire. The students completed the scale in about 30 minutes.

The data were prepared in SPSS and the missing data analyses were conducted. Then, MANOVA analysis was conducted by using SPSS. Later, the structural equation modeling analyses for both genders were conducted by using LISREL. The modifications recommended by the program which were consistent with the literature were also included in the modeling analyses.

Data Analysis and Results

The mean scores and the standard deviations for each sub-scale and the affective characteristics scale for males and females were presented in Table 1.

Table 1. Means and Standard deviations for female and male freshmen

Number of items in the subscale	Subscale	Female		Male	
		Mean	SD	Mean	SD
4	INTFC	11.07	4.33	11.17	4.19
5	İNTPC*	14.67	5.03	16.25	5.00
5	IMPPC	13.69	3.43	14.05	3.39
4	IMPFC*	15.77	4.51	16.59	4.57
7	ASPEXT*	22.81	7.03	26.37	6.86
4	SMOT*	10.73	3.74	12.48	3.88
4	ACHMOT	13.94	3.36	14.37	3.25
5	PTANX*	10.76	4.78	13.10	5.45
5	PCANX*	15.14	4.96	16.58	4.96
5	PSEFF*	16.29	4.16	17.95	4.31
5	PSCON*	13.95	3.96	15.54	4.48
53	AFFECT*	159.35	34.06	175.07	34.81

* Significant differences were observed in the MANOVA results

A one-way multivariate analysis of variance (MANOVA) was conducted to determine the effect of gender on freshmen's physics related affective characteristics. Significant differences were found among gender groups on the dependent measures, Wilks Λ =.864, $F(11,825)=2653$, $p=.000$. The multivariate η^2 based on Wilks' Λ was .14, indicating 14% of multivariate variance of dependent variables is associated with gender.

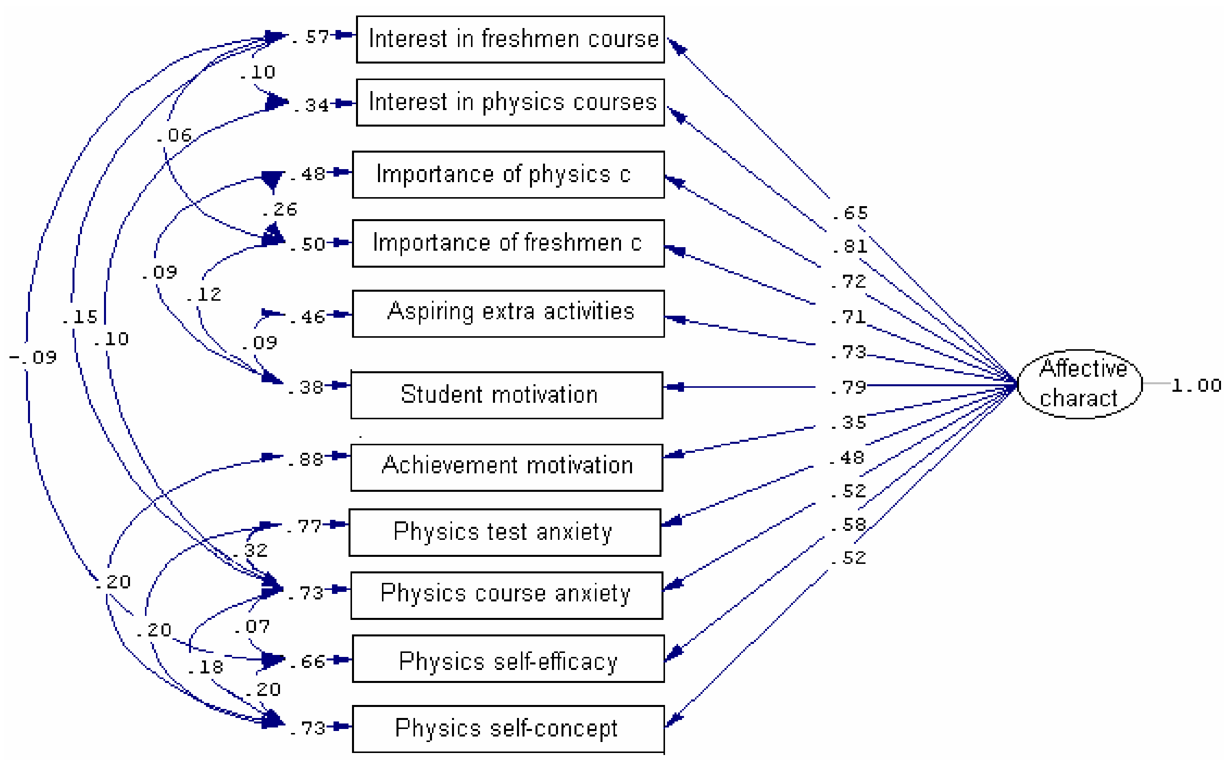
Analyses of variances (ANOVA) on each dependent variable were conducted as follow-up tests to MANOVA. Using the Bonferroni method, each ANOVA was tested at the .0042 level. The ANOVA on INTPC ($F(1,835)=20.974$, $p=.000$), IMPFC ($F(1,835)=8.301$, $p=.004$), ASPEXT ($F(1,835)=55.228$, $p=.000$), SMOT ($F(1,835)=45.371$, $p=.000$), PTANX $F(1,835)=43.025$, $p=.000$), PCANX ($F(1,835)=19.314$, $p=.000$), PSEFF ($F(1,835)=33.513$, $p=.000$), PSCON ($F(1,835)=27.119$, $p=.000$) scores were significant. Whereas, the ANOVA's on INTFC, IMPPC and ACHMOT scores were non-significant.

Structural Equation Modeling

Structural equation modeling allows researchers to test the models which are theoretically derived from the literature. There are several indices for testing the fit of the sample data to the theoretical model. Chi-square (χ^2), root mean square error of approximation (RMSEA), goodness of fit index (GFI), adjusted goodness of fit index (AGFI) and Tucker-Lewis Index (TLI) are used to test the fit of sample data to the proposed models in this study.

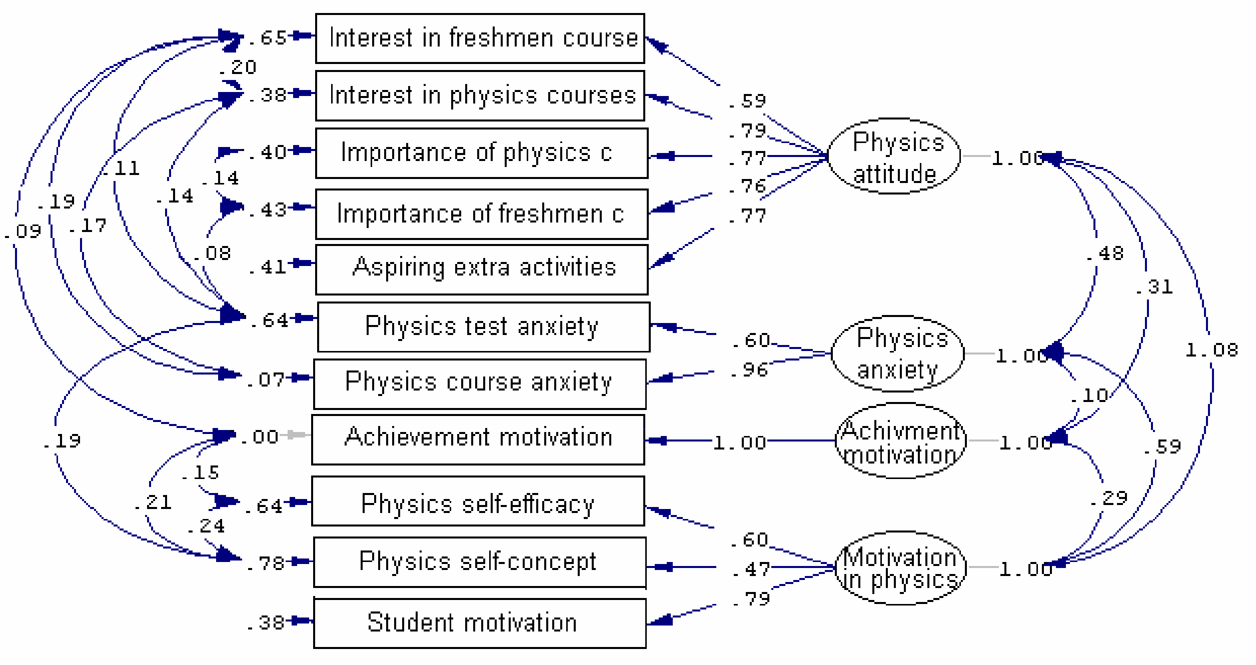
The unidimensional model exhibited the best fit for female freshmen (χ^2 (29, N=433)=58.18, $p>.05$, RMSEA=.048, GFI=.98, AGFI=.95, TLI=.97). Standardized values of the model were presented in Figure 3. Moreover, all the t-values were significant in the model at .05 level of significance.

Figure 3: Standardized values of the best fitting model for females



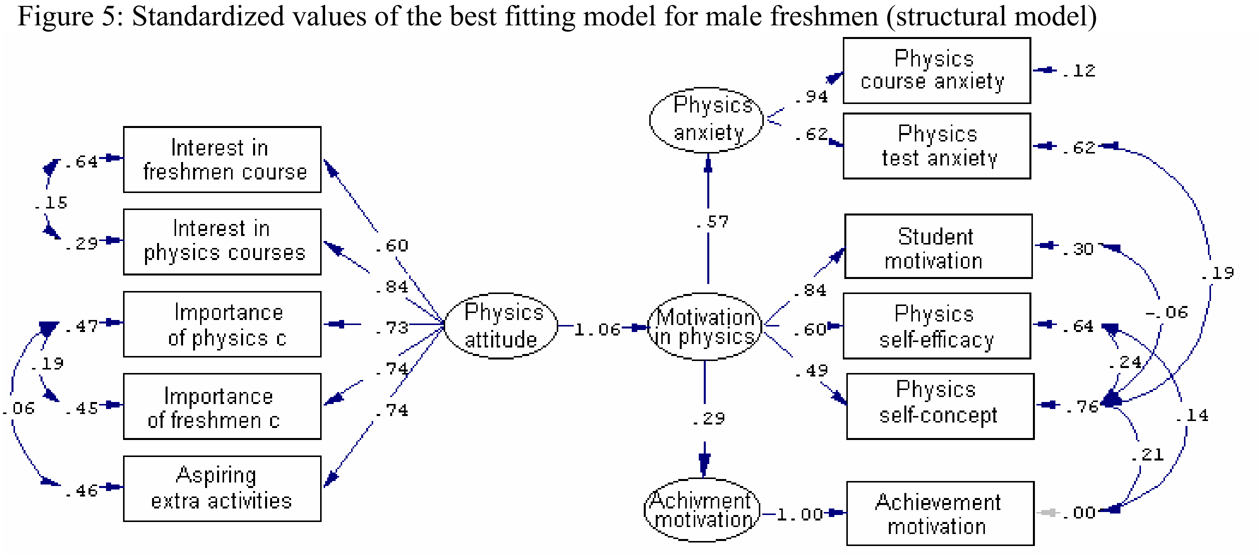
The multidimensional model exhibited the best fit for male freshmen (χ^2(33, N=435)=89.02, *p>.05*, RMSEA=.063, GFI=.96, AGFI=.93, TLI=.96). Standardized values of the measurement model were presented in Figure 4. Moreover, all the t-values were significant in the model.

Figure 4: Standardized values of the best fitting model for males (measurement model)



The multidimensional model exhibited the best fit for male freshmen (χ^2(30, N=435)=63.14, *p>.05*, RMSEA=.050, GFI=.97, AGFI=.94, TLI=.97). Standardized values of the structural model were presented in Figure 5. Moreover, all the t-values were significant in the model.

Figure 5: Standardized values of the best fitting model for male freshmen (structural model)



Conclusions and Discussion

There is enough evidence for the differences between males' and females' affective characteristics in the literature. However, there were no studies which compared models for males' and females' affective characteristics. Results of this study revealed that the structure of males' and females affective characteristics were different from each other, thus developing common models for males' and females' affective characteristics is not accurate.

While one of the proposed models, the unidimensional model exhibited the best fit for female freshmen, a new model similar to the multidimensional model was the best fitting model for male freshmen. However, there were more factors in this model than the proposed model. Physics attitude has only direct effect on physics motivation in this model, and motivation has direct effects on ACHMOT and physics anxiety. This model is consistent with the results of the overall (males and females) model developed by Gungor et al (2006). However, females' model was not consistent with the overall model. Thus, any treatment done in line with the overall model will be acting in favor of boys.

There is a clear order of the sub-dimensions for females. INTPC, SMOT and importance of physics courses were the most influential sub-dimensions defining affective characteristics for females. On the other hand, males have a more complicated structure in the model than females. Thus, while trying to develop students' affective characteristics males and females should be treated differently.

Male freshmen were more interested in topics related to electricity similar to the literature (Häussler, 1987; Sencar & Eryilmaz, 2004) and males in this study had higher self-concept than females similar to Martin et al (2000). However, in general it is not accurate to say that males have more positive affective characteristics than females, since three of the factors (INTFC, IMPPC and ACHMOT) in this study were comparable for males and females.

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An interdisciplinary curriculum for high school students involving Physics education

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Abstract

In the context of the prevailing challenges in education, one of its crucial goals is to endow the students with an ensemble of functional competencies. Therefore, educators across the globe have been developing new strategies in which active learning plays an important role, creating a student-centered learning atmosphere. That also demands a transformation of teachers involved in edifying innovation to introduce new curricula adapted to the specific situations. Our proposed curriculum takes into account both the contemporary trends of education and the necessary state of affairs for its implementation. It is an interdisciplinary approach in terms of CDIO (Conceive, Draw, Implement and Operate) that can be adapted and implemented to the high school level. We have tried to initiate, within an optional class, a project based-learning atmosphere, involving the subjects of Physics and Informatics under the guidance of two teachers skilled in the respective fields. This paper presents the input, the process and the possible output of this curriculum along with other issues related to our purpose.

Introduction

Over the years, the concept of teaching has been modified to introduce a comprehensive framework with the unique aim of exclusive involvement and capitalization of students abilities. In the modern education, “active learning is a key element expected to increase student motivation, commitment and retention” [1].
It is known that, in the traditional approach of teaching the main active personage is the teacher who is supposed to deliver lecture while students listen and observe the lecture and pay deep attention to take notes. This teacher-centered model of teaching has become today not only unfashionable, but also less efficient. The idea of active learning has its roots as far back as 490 BC, when Socrates used problems and questions to guide students to analyze and think about their surroundings [2]. Today, many progressive educators have developed and emphasized this method, applying it at all levels of education. Instead of being passive recipients, learners have become involved directly in the process of teaching. This method bestows a higher responsibility on students, though it does not relieve teachers from their obligations. Moreover, students prefer active learning techniques comparing to the traditional methods, because they entail more spontaneity, flexibility, diversity and just amusement [3].

Another modern concept is interdisciplinary education. True interdisciplinary education was developed today by many colleges and universities, who demand that researchers should not be stuck in traditional subjects. The new interdisciplinary programs are taught by at least two teachers from each of the participating disciplines.

Contents and reasons

Starting from these two basic concepts (‘active learning’ and ‘interdisciplinary education’), we have conceived an innovative curriculum for the students in the last year of study (12^{th}

grade) in a high school in Romania, which intends to connect their knowledge in Physics and Informatics.

A brief overview of our innovative curriculum is shown in figure 1.

This curriculum is addressed to mathematics-informatics profile and the class is scheduled as one hour per week as an optional type of class on any integrating topic. This type of curriculum is a form of "Curriculum at School Decision (CSD)" that includes:

-new competencies of integrating and transferring knowledge between common disciplines;

-new content which connects at least two disciplines.

The role of a single teacher is replaced with a team of two teachers who assume different responsibilities according to their abilities, interests and experiences [5]. The target of the curriculum is to let the students conceive, draw, implement and operate, in a CDIO framework adapted for a pre-university level, a set of lessons focused on the first level of studying Physics (6^{th} grade). The concept of CDIO has been incorporated by many engineering educators in universities in order to reconsider and develop both the curriculum and the teaching methodology for undergraduate programmes [6]. We considered that CDIO system can be rather easily adopted in the last grade of the high school with some specific adjustments.

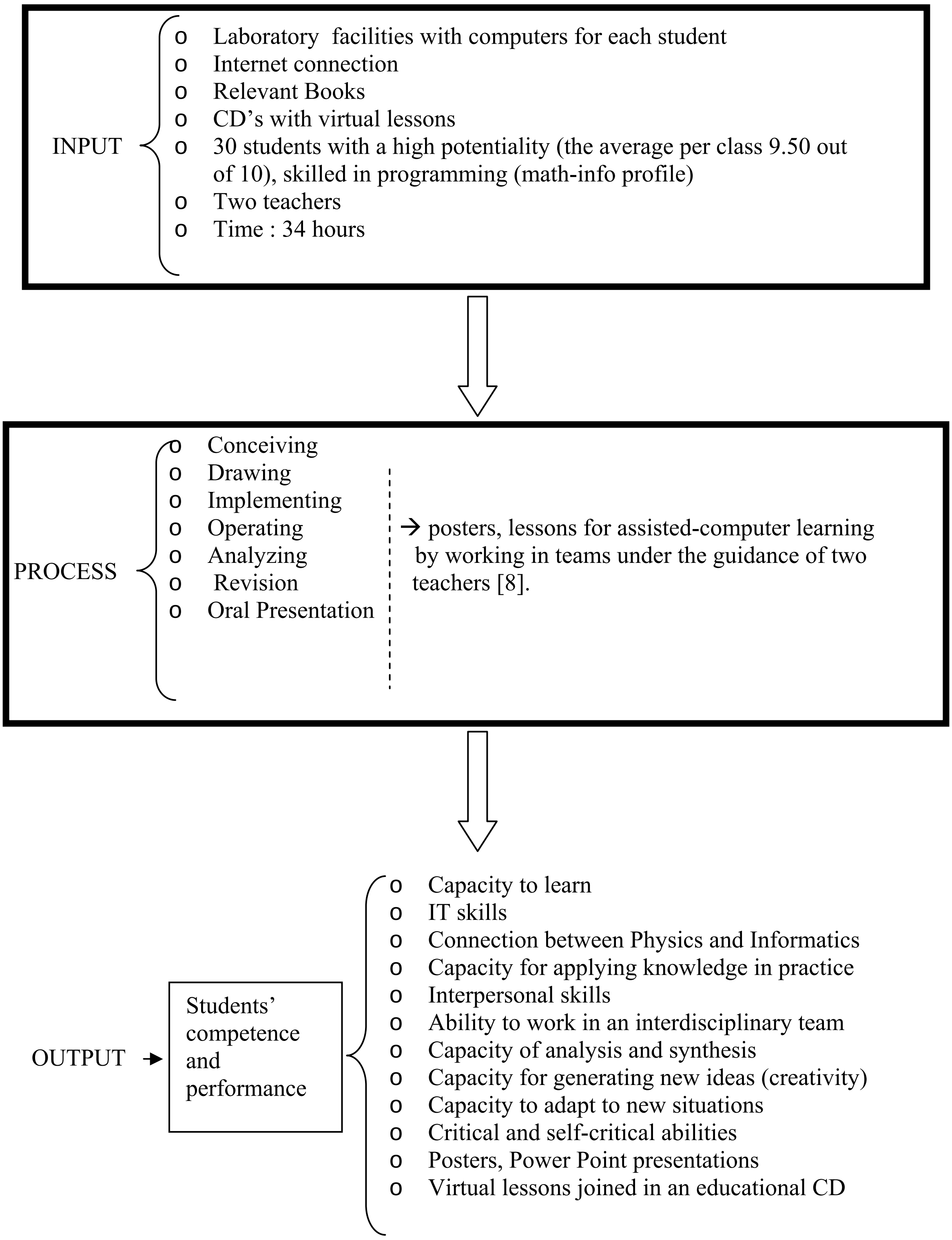
This curriculum concerns a laboratory which is supposed to encourage and engage the best students with in-depth knowledge both in Physics and IT by the process of creating exciting didactic materials for teaching 'basic concepts in Physics'.

It is organized in following two modules according to the semester repartition of hours:

The reasons for developing this new curriculum are:

- interdisciplinary approaches in Romanian high schools are weakly represented;
- the students in mathematics-informatics profile, especially in the final years, are very interested in some programs like Flash, Swish, Visual Basic, HTML, but have few opportunities to apply them in the school in solving practical problems;
- many of the students from mathematics-informatics profile are directed toward engineering profiles in their future academic studies and Physics is also a subject in which attract them;
- engaging students in remembering, thinking and rendition of some basic concepts can both strengthen their knowledge and help them to evaluate their achievements [7];
- working in groups, students can develop abilities to take the responsibility of any given assignment in university level;
- students have total freedom within these lessons and that offers them the opportunity to develop their individual skills in some areas which are not included in standard curricula;
- processing abstract ideas in concrete material affords the opportunity not only of a long term involvement of students but also of a feedback which obliges them to reflect upon their works, to raise new questions, to criticize their "products" and finally to augment their results that ultimately give them satisfaction.

Figure 1



This curriculum is a part of the Romanian reform of education which was conceived in 1997 and announced as a number of collective measures, among which the curriculum reform is the first one. It is clear that in any project of curriculum change a main role is detained by the teachers who have to adapt and rethink their activity in order to optimally conform to the educational objectives. The point of starting to implement the two modules was the competencies which are expected to be obtained by following the proposed modules. In addition, we considered the following:

- human and material resources in a school are better known by the teachers from that school;
- in the light of a de-centralized education, it is absolutely necessary that each teacher be a dynamic player who offers, according to his pedagogical and professional abilities and personalized curricula answers to queries from his students
- a specific curriculum increases the democratic participation of teachers and students in taking decisions regarding the content of school education as well as entailing the enhancement of the school quality.

Moments of the project
Preamble

In this part, each module is depicted from which the students can be acquainted with the goals and content of the curriculum. The teachers present also the benefit of the achievement of Physics lessons on computer. Examples are given through some presentations which are not supposed to be modules, but starting points or sources of inspiration. At the same time, the teachers provide the necessary materials (books of Physics, CD's, list of references). Two hours are allocated for the teachers of the team of educators, to present their own specific roles and recourses. In this "moment" the students are told that they will work in teams during the whole module. A team is constituted by five students ("experts") who possess complementary abilities and who contribute to the achievement of the project. The "experts" have to be skilled in: Physics, IT programs, editing, drawing and compilation. For the first semester the final objective for each team of students is to achieve a poster and a Power Point presentation for one of the following chapters: physical quantities, mechanical, thermal, electrical, optical or magnetic phenomena. The same topics may be transposed as sophisticated lessons in a suitable computer device which will form complete educational software for teaching Physics in the future at any appropriate level.

Team formation and repartitions of topics

The students are supposed to think one week about their preferences and, with the help of the teachers they will form then the five-group. Each team will have a leader who is openly elected/selected both by the teachers and the students. Then, the teachers assign a topic for each group. This is just the moment when a brainstorming is going to be started.
The students have to revise the general notions related to their topic in Physics from a school book, as homework. For the second semester it is better to keep the same groups, but in special cases students can join from a group to another, according with their abilities and preferences.

Conceiving and drawing

The class is unfolded in the laboratory of informatics where the computers are connected to the internet. The teachers, along with the students sketch the content of a lesson which does not have to be mandatory standard one (giving students a certain freedom in accomplishing their tasks). Generally, each lesson contains an eloquent title, preferably a motto which can be a catchy one, textual content, virtual experiments or animated images (for the projects in the second semester), conclusions, short stories related to the topic, summary and tests. The students along with the teachers establish the technical details about the applications used for creating the projects. In the second semester, this is the "moment" when the teachers and students discuss also about the accumulation of all the projects in unique educational software and the interface from which the lessons are launched. The responsibility of gathering all materials is ascribed to a student.

Implementing and operating

At this point the students, assisted by the teachers, pass properly to creating the lessons on computer. The teachers have to survey the activity and verify the accuracy of the scientific content. They also help students to solve some problems which could appear during this process and help to estimate the time that is to be allocated for every step. Each project must

Table 1: Annual scheduling

Semester	Specific comments	Moments of the projects	Time (h)	Assessment
First Semester	-recognizing, recalling, interpreting, exemplifying, classifying, summarizing, inferring, comparing, explaining, analysis, synthesis concepts in Physics -using internet and other resources to obtain information -developing oral presentation skills	Preamble	2	-systematic monitoring of the students behaviors
		Team formation and repartition of the topics	1	
		Conceiving and drawing lessons	4	-self assessment -oral presentations
		Implementing and operating	4	-papers, posters, educational CD
		Revisions and oral presentations	3	
Second semester	-enhancing IT skills -implementing IT notions in conceiving Physics related materials and lessons -developing the scientific language -developing of critic and self-critic appreciation skills -experiencing team work	Preamble	2	
		Reformation of the teams and repartition of assignments	1	
		Conceiving and drawing lessons	8	
		Implementing and operating	10	
		Revisions and oral presentations of the educational CD	3	

be accompanied by an electronic handbook. Being allocated only one hour per week, this discipline is based also on homework. For the second module, the teachers along with students elect a leader, expert in IT, in order to accumulate all lessons and to insert an accessible and friendly interface for launching them. The group leader will obviously work under teachers' guidance.

Revision and oral presentation

Each project will be examined and tested. A project will be transferred to one or two other teams for a peer review to mend any disfunctionalites. At the end, the teachers verify each project and then the students present their work in an open meeting together with other students and teachers.

Conclusions, discussions and expectations

In the context of the huge impact of information, the educators taking responsibility to find ways of catching the learner's attention is a crucial key for successful implementation of the process. On the other hand, the development of students' abilities demands a dynamic system of education. Moreover, there is a rapid progress in sciences and that demands a continuous readjustment of school curricula to the new needs of society. Our proposed curriculum takes into account these requirements. In addition, the CDIO concept, applied in pre-university level, offers a proper frame to reach to our target.
We consider that our curriculum is one that brings and applies active learning strategies, connecting more disciplines, fostering creativity and enabling students to become more responsible for their own instruction. In addition, cooperative learning appears to be a promising method by which students can simultaneously achieve both academic and socio-moral skills [8].
We are conscious of the difficulties of fulfilling such a curriculum in the current educational environment. The main problems could be:

-inclusion this curriculum in the present legal frame
-disinclination of some students and, perhaps, school staff
-lack of experience in such interactive curricula regarding the teachers who will direct it
-assessments of the students in this class
-collaboration/communication in teams (in general, except sport class students are not accustomed to work in teams), possible tensions;
-the respect of timetable in accomplishing of the proposed software, etc.

Our positiveness about the success of this proposed curriculum is based on students potential, teachers enthusiasm and the proper learning environment (lab with PCs and internet connection).
We expect that the efficacy of these lessons to be reflected in:

-captivation of students attention
-relevance of previous knowledge and capitalization of it
-increase of confidence
-exuberating satisfaction [9]

The positive features and expectations of this curriculum encourage us to conclude that it is worthy of implementation. We are convinced that, with such a great input, the success of this new curriculum can be achieved, both the teachers and the students being winners after experiencing this challenge.

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