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The Interaction Between High School Curriculum and First Year College Courses: The Case of Computing

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ABSTRACT

Many countries, including those in the developing world, have introduced mandatory Information Technology (IT) courses for high school (HS) students. This was motivated by the importance of IT skills for the general population in view of the widespread use of computers. The HS curriculum is frequently decided upon by university faculty, with university needs very much in mind. A steady shift of introductory college level material to HS curriculum is observed. With all the positive effects of IT HS education, the issue of how to modify the first year computing courses to account for the material transferred to HS had to be addressed. The problem is complicated by the nonuniform adoption of IT education in high schools even within a single country, the varying emphasis on theory vs. practice in HS courses and the differences in the availability of resources at high schools, inadequacy of testing procedures and, in the case of many developing countries, the language of instruction difference between HS and college. Ignoring the HS curriculum when designing college level courses is a waste of resources and may render the college classes boring for many students. Accounting for the HS computing education at the college level may require a suite of placement tests. Even then, it may not be straightforward to figure out how to modify each of the introductory college courses to account for the HS material. On the example of the completely revamped IT education in Palestinian schools, which introduced mandatory technology education for grades 5-12 for all HS students, we discuss the dilemma of how to account for the HS IT knowledge and skills at the college level, especially the way this should affect the first computing courses at the college level, which has been a topic of debate in the last years.

Categories and Subject Descriptors

K.3.2 [**Computer and Information Science Education**]: *Computer science education*, *Curriculum*

General Terms

Design, Standardization.

Keywords

High School Curriculum, K12 Computer Education, Computer Science Curriculum, Model Computer Curriculum.

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1. INTRODUCTION

In many countries there is strong realization that computing skills are essential for citizens being able to lead their everyday life in an efficient manner and to benefit from the multiplicity of information technology based services that are being offered. The average citizen's need for these skills has been continuously shifting to earlier ages. Even school students find it essential to use the Internet for their research assignments and to use computers to write reports, give presentations and to gain access to the ever expanding IT-enabled educational resources. Web based sources such as dictionaries and the Wikipedia are proving popular with a growing number of students. Internet based social networking is gaining acceptance for many, including kids. Modern communications and gaming are having more of the characteristics of computing. Additionally, computing has established itself as a discipline and potential career path to which students may need to be exposed in sufficient depth and breadth to be able to make informed career decisions in the future.

To meet the demands for computer literacy, many countries have resorted to including Information Technology as a study subject early in their education system. For example, in Palestine, IT studies start as early as the fifth grade and continue, in increasing doses, till high school matriculation. While early on, concentration may be on skills and general concepts, later study shifts to the basics of computing. These are topics that have been traditionally covered at the college level. This applies to both the skills needed by non-IT college students that are very much covered in HS and also some of the material in introductory college computer science courses. This implies a shift of material that has been part of the college IT education to the high school level which may necessitate adjustments in the college curriculum. The adjustment task is not a straightforward matter. It is complicated by factors like the high school material having the breadth, but not necessarily the depth, of college courses, the nonuniform nature of the preparation of incoming students, the differences in the language of instruction, the testing approaches and the rigor in which the material is covered at various levels and the rapidly changing nature of information technology which may render skills/knowledge obsolete fast.

In the remainder of this paper we will discuss the issue of the interaction between high school curriculum and college curriculum on the example of the Palestinian school system which introduced compulsory IT education for grades 5-12. We first describe the Palestinian educational environment then we report on our experience in adapting the college IT material to take into account the skills/knowledge of incoming students and the problems associated with that and the way things may develop in the future.

2. THE ENVIRONMENT

In this section we outline the state of high school and college technology curriculum in Palestine to highlight the issues raised by the recent developments in this area.

2.1 High School Curriculum

The Palestinian educational system has undergone dramatic changes with the introduction of the unified Palestinian curriculum starting 1995. Unified because it was adopted in all Palestinian schools in all parts of the Palestinian territories: the West Bank including East Jerusalem and Gaza. Earlier the former had a curriculum heavily influenced by the Jordanian system and the latter had a curriculum heavily influenced by the Egyptian system. One of the new features of the new curriculum is the adoption of English instruction from first grade and the introduction of technology education from grade 5 on, for all students of all streams (science, arts and vocational) and in all schools (public, semipublic and private). On the average students learn technology for 2 hours a week in every one of grades 5-12. The topics covered include engineering drawing, material sciences, electronics and digital circuits, electricity and protection and information technology. IT features prominently at all levels and in the last 2 grades of high school (grades 11 and 12) only information and communications technology (ICT) education is offered. As is the case for all other subjects, the language of instruction for technology and IT school education is Arabic. The first class of students who completely followed the Palestinian curriculum graduated from HS in 2006 and are currently in their sophomore year at college. Currently, the total number of students in Palestinian schools is 1,104,208 students evenly split between males and females. The number of those getting some sort of instruction in information technology is 571314 of which 285,126 are females (Grades 5-10). 142,481 students, of which 75,312 females, are being instructed in IT alone (grades 11 and 12)[4]. The original plan envisioned that 5.6% of educational hours be allocated to Technology and Applied Sciences[5] with 2 weekly hours devoted to these subjects for the 8 academic years of grades 5-12. The current school curriculum adheres closely to this vision[5].

On average, information technology occupies about one third of technology instruction in grades 5-10. Topics covered include basic Internet search, communications basics, basic computer algorithms and programming (Visual Basic), computer ethics and social implications (though not as a distinct topic) and basic computer construction. Packages covered include word processing, spreadsheets, computer based technical drawing, and more. For grades 11 and 12 the topics covered and the hours devoted to each are given in the following table[5]:

#	Topic	(Grade) Hrs First Semester	(Grade) Hrs Second Semester	**Total Hrs**
1	Basic Computing Concepts	(11) 10	(11) 5	**15**
2	Problem Solving, Algorithms and Programming	(11) 13	(11) 20	**33**
3	Communication Networks and Internet	(12) 11	(12) 10	**21**
4	Multimedia and Web Design	(12) 15		**15**
5	Databases		(12) 15	**15**
6	Computer Maintenance	(11) 15		**15**
Total hours 11th grade		38	25	63
Total hours 12th grade		26	25	51
Total Hours		**64**	**50**	**114**

Table 1: IT Education for 11th and 12th Grades, all Streams[5]

One of the main problems facing technology instruction in Palestinian HS is the insufficient resource availability, both instructors and laboratory equipment. The diverse material covered in the technology curriculum makes it difficult for teachers in traditional disciplines to teach the multiplicity of topics at a reasonable level. The pay levels make teaching unattractive to computer science and engineering graduates. While certain universities are beginning to offer degrees in *teaching technology* at HS, the outcome is still in need of evaluation. Many schools do not have adequate laboratory resources in terms of numbers, availability and quality in the rapidly changing field of IT. Additionally, the need for regular revision of school curriculum to account for technology development and lessons learned was evident from the start. However, for various reasons the revision was substantially delayed and only started recently.

2.2 College Curriculum:

Most Palestinian universities require all their students to take courses in computing, with minor variations between schools[8]. For example, computer instruction is compulsory for all students at Birzeit University (8000 students, 56% of which are females)[3]. Students have to take one of the following two courses:

2.2.1 Basic Computer Programming; for the scientific colleges, in this case colleges of Engineering, Information Technology and Science. This mandatory course teaches basic computer programming with an introduction to computing and algorithms. Calculus is a prerequisite for this course but no computer skills are assumed. The language of choice varies and the course has a

major lab components where students practice hands on programming under the supervision of their instructor.

2.2.2 Introduction to Computing: for the social sciences, commerce, law and public administration students the required course is non-technical introduction to computing that surveys basic computer architecture but focuses on the basic skills including operating systems, word processing, spreadsheets, presentation software with emphasis of Microsoft Office suite, and web search and ethics. While this is a freshman level course, many students tend to delay taking it until later in their university education. There are no prerequisites for this course and it assumes no previous computer knowledge or mathematical skills. The language of instruction for the computing courses at the college level is English. However, subject matter instruction at the colleges taking the introductory non-technical computer course is mainly in Arabic. The students taking the non technical computing course are of varied backgrounds in terms of their mathematical knowledge and computer skills, as many college majors accept HS graduates from both scientific and social sciences streams. However, the policy is to have all students, independent of their backgrounds, take the same course in mixed sections. The university has no policy of requiring a placement exam or a waiver for people with computing skills, though the university has an elaborate system with placement tests and varying university requirements for English language proficiency.

Now that the incoming class has been heavily instructed in computing, both at the technical and skills levels, the previous introductory offering is no longer sustainable. Retaining the same course content is a waste of resources since most incoming students have the skill level sought by the course. The situation is more complicated during the current transition stage when students have widely diverse computing backgrounds due to the varied HS experiences.

3. THE PROBLEM

In this section we address the problems facing the interaction between HS and College curriculum at two levels; that of the general, nontechnical computing course mandatory for students outside science and engineering and technical computer courses required for science/engineering students.

3.1 General Computer Skills Course:

The content of the traditional skills based nontechnical college computer course for non science/engineering students is almost fully covered in the HS curriculum, certainly in breadth and to a large extend in depth. One main difference is that the HS curriculum is delivered in Arabic while the college level course is basically in English. Also much of the instruction at the college level is delivered in the lab using a hands-on approach. To account for the overlap between HS and college material three options have been under consideration:

1. Mostly stick with the old college content on the assumption that it never hurts to refresh the required skills, more so that many of the skills have been taught a long time ago, used older versions of the applications and also to account for the language switch and the change in instruction mode. The drawback is the wasted resources, the weak motivation for students to do well at the school level and the false impression this approach creates about the nature of university instruction.
2. Assume that students already have the skills required and scrap the college level computer literacy course in as far as it touches on issues covered in school curriculum. The main drawback here is that the skill level may not be sufficient or uniform for all students because of the different levels of exposure to lab work and the skill levels of the teachers and availability of resources during HS years. This approach will perpetuate the weakness of certain students in IT skills and will make it difficult for the university departments to make assumptions about the IT skill levels of its students and to incorporate that into curriculum design.
3. Build on the HS curriculum and direct the college course to areas not covered in HS be it breadth-wise by selecting topics of interest to students but not covered in HS. Such topics may include discipline specific packages: e.g. SPSS for social sciences, E-commerce for Commerce students, law reasoning programs for law students. Or depth-wise by having students go deeper into topics already covered in high school. Examples are more elaborate use of word processing packages, more advanced features of presentation software, and so on. Once more, the nonuniform nature of student preparation and the difficulty of building on their previous knowledge is an obstacle to such an approach. The need for in depth coverage may not be evident for the regular packages for non-IT experts.

3.2 Technical Computing Courses:

As for the technical IT courses, the intersection between high school material and several college level courses is substantial. However, none of the technical IT college courses is completely covered in high school curriculum. The following points are evident:

1. While students study algorithms and data structures, the depth is not college level. Students touch on basic *sort* and *search* algorithms but without theoretical analysis. The reason is that the high school material doesn't assume the mathematical skill assumed for the college courses since it is delivered to students with widely varying backgrounds. This may apply also to Databases.
2. The programming material may be substantial. However, the language of choice (Visual Basic) is not the same as that for college (C, Java,…). The problems and projects in HS are simpler in nature than those one would expect at the college level.
3. The computer basics covering the foundation of computer construction, CPU components and operating systems are shallower than the material covered in an introductory computer organization course at college. Similar reasoning will apply to database and communications material.
4. The switch in the language of instruction from Arabic in High School to English in college is present in all components.

Nevertheless, two points are clear. The HS material covers the introductory material in several courses and makes some of the concepts offered there familiar to the degree that they can be skipped. Certain students may have done much better than others in HS to the degree that they can skip one of the basic computing courses or they can realistically take an alternative, more advanced, course in place of the basic one.

This content overlap problem is not unique to computing. There is substantial degree of duplication between the HS material and the introductory college courses in the sciences as well. The overlap there is much more evident to the degree that the first mathematics, physics and chemistry college courses are more than 80% covered in high school at similar depth though in Arabic. These courses are prerequisites to more advanced courses in the respective discipline. This is troubling many people designing curricula, say in engineering, where they don't appreciate the need to restudy the HS material before proceeding to new stuff and the associated loss of highly sought after credit hours. One of the factors hindering changes are the comparisons with other countries whose students may not have overlapping material and the fear of loss of teacher load by the respective departments. We believe that any solutions applicable to computing will be more so to introductory science courses.

4. POSSIBLE SOLUTIONS

Here too, we offer the solutions to the problem at hand in two phases: general, nontechnical and technical computing. Our solutions were justified mostly by the local experiences. It seems to us that the widespread computer curricula recommendations for high schools[1] and undergraduate college levels[2] do not explicitly address the issue considered in this article despite the specification of various models for K12 curriculum, including the Advanced Placement (AP) targeting students who plan a career in computer science, business or related fields[1].

4.1 General Literacy Computing Course:

A uniform solution that calls for having all students attend the same course seems to be problematic no matter what the nature of the course offered is. Students mathematical backgrounds are different since several colleges accept both science and arts streams HS graduates. Requiring stronger mathematical content will render the course inaccessible to arts students. A descriptive non-math based course will be too easy, and even dull for the science stream students. Offering two different college courses to account for varying student math skills is another option. However, this may be difficult to justify since both groups are majoring in the same field and their IT needs should be the same. However, if handled properly, having students with varying IT skills beyond the minimum required in a class may be desirable by having students learn by example from their colleagues with more advanced IT skills.

The other option is to have a skill based course, with a clear designation of the skills that a student must develop by the end of the course. The level of the course must reflect the stage at which these skills are required. For example, with the current emphasis on writing, presentation and Internet research skills, the course is better offered at the freshman level. Students will be required to take a placement exam to determine the degree to which they meet the skills proficiency. Those who do well are exempted from the course and those who don't are required to take the course as a remedial, and still skills based course. They need to retake the test once again after they take the course. However, contrary to the current practice, students will be able to repeat the course only once after which they have to pass the test on their own. The testing process may be independent of the college and one may refer to standardized tests such as ICDL to guarantee consistency and test neutrality.

4.2 Technical Computer Science:

Since no single university course is rendered completely redundant by the material covered in HS, the courses with substantial coverage must be modified to account for the overlap, both in depth and breadth. While the instructor can still survey the HS material, that must be done minimally and in a volume that will help students reload the context. Using this approach we estimate that certain courses may be reduced by about 30%, an amount that can be used to go deeper into new material and extend the course coverage. It may be the case that the coverage of the college level material can be accomplished in less courses, or les credit hours, than is currently possible. The savings can be used to add totally new courses to the college curriculum to account for newer trends and more advanced topics. Historically, departments were interested in exceeding the number of hours allocated for the programs they are offering so such an approach will alleviate this restriction. If at any later stage it transpires that certain college courses are (almost) completely covered in HS these courses should be treated as the fully covered non technical course.

One problem with this approach is that the level of incoming students may not be uniform. Instructors may find it difficult to go deeper into the course when not all their students are adequately skilled in high school material. We believe that the way to go around this is to assume that each student has good knowledge of the HS material and for the college curriculum to be based on this assumption. The skill/knowledge level of students must be tested through an entrance/placement exam. Students found to have inadequate skills may be required to have one or more remedial course to bring them up to the required standard.

4.3 Remedial Nature of Introductory Courses:

We would like to emphasize that we are advocating the use of remedial courses to bring all students to the required skill level. The usual practice has been to use the "when in doubt redo the high school material at the college level" approach. We believe that the current approach is counterproductive in more than one way. There seems to be no clear evidence to indicate that the repetition helps improve the skill level substantially. On the negative side, many students find the repetition boring and are getting a false impression about the novelty of university education. On the positive side, under the new approach students will

tend to take HS curriculum more seriously and invest more in getting the required skills to avoid the college level repetition and the associated costs. One additional advantage is that if designed well, the entrance exams will reflect positively on the type of material emphasized at the school level where traditionally much memorizing is the common approach as opposed to critical analysis and thinking. High school teachers are bound to take notice of the skills needed and to start stressing them in their instruction. One may even predict a situation where the general HS matriculation exams merge with the entrance exams offered by universities to the advantage of not only the educational system but also to the market through students who do not enroll in college.

We anticipate some difficulties in adopting any of the mentioned solutions. Academic considerations may not be the only factors affecting the decision on the possible solution to the problem. Issues like student and faculty members readiness /resistance to adopt these solutions and the associated changes, the need for monitoring procedures to evaluate the new course content and delivery methods are real obstacles that need to be overcome. Logistics and cost considerations, especially those associated with administering proper, skill-based placement exams for a large student population may also prove a real problem that may require a nationally coordinated effort to minimize overhead and to eliminate duplication and spare students the need to take a multiplicity of exams for several schools they are considering applying to.

5. CONCLUSION

In this paper we have addressed the issue of how the increasing doses of high school information technology education can influence and be influenced by the content of introductory computing courses at the college level. We argued that taking account of the interaction between the two is not a trivial matter and may have profound implications for the types of skills high school students achieve, the mode of course delivery and testing used at HS. We advocated the use of placement tests, initially administered by colleges, to determine the computing knowledge/skill level of incoming students and to require students not passing a given threshold to take remedial courses, thus giving a clear advantage to students with better HS skills as opposed to the current practice of requiring all students to (re)take material generally based on least common HS skills of the incoming students. This approach may be as relevant to two year community colleges[7]. It need not be unique to computing but can be easily extended to other disciplines as well. We believe that this approach has the added advantage of being adaptive to future changes to HS and College curricula, a frequent occurrence in a field characterized by rapid changes in technology and systems. This dynamism is lacking in the traditional educational system characterized by its high inertia, and which has been struggling with how to incorporate into the HS matriculation exams disciplines with a major practical/skills component such as IT courses.

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