

Diversity in the Development of Computing Projects

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Abstract

Developing projects in computing-oriented courses is a well-known practice. However, the dynamic nature of the computing sciences poses new challenges for students and their instructors. They have a direct influence on the diversity in the project development aspects: diversity of the project types, topics, goals, participation, presentation, assessment, applications, and ethical issues introduced in the project. The concrete academic environment should be also considered when assigning projects of different types. The job market of computing professionals also plays an important role in the selection of appropriate computing projects. The theoretical and practical orientation of the related work requires the student to display imagination, originality, significant knowledge and skills and even multidisciplinary vision in most cases. Very often, the complexity of the computing projects requires the students' close collaboration in teams. This paper considers the variety of projects developed in liberal arts environment and presents their role in obtaining a strong background for the future students' activity after the graduation from the respective academic institution.

1. Introduction

Teaching computing disciplines involves a significant number of projects periodically assigned to students. Developing projects is a multilateral process having different aspects (Figure 1). This is an opportunity to cover the academic requirements relevant to a given course. Students majoring in specific computing areas are able to obtain knowledge and skills in using a variety of commercial software products and a strong background in practice-oriented professional activities. This way, they are prepared for their future job and for pursuing a higher academic degree. These educational challenges lead to specific visions expressed by students, instructors, and industry and society.

Students are interested in acquiring professional skills by using the most recent software products that allow their immediate implementation in internship activities or other current or future job responsibilities in addition to students' academic studies.

Instructors' aspects focus on covering the curricula requirements, providing the needed theoretical background to students, incorporating the practical orientation of the material taught, and educating appropriate ethical and moral principles.

Industry needs knowledgeable workers, skilled software and hardware users, and software engineers who are capable of accomplishing miscellaneous computing applications and are valuable members of the society.

The development of computing projects reflects the above three views and leads to the achievement of important results such as acquiring relevant knowledge and skills needed for the future students' profession and graduate studies, providing opportunities for undergraduate research and practice-oriented applications, and adopting appropriate professional ethical behavior.

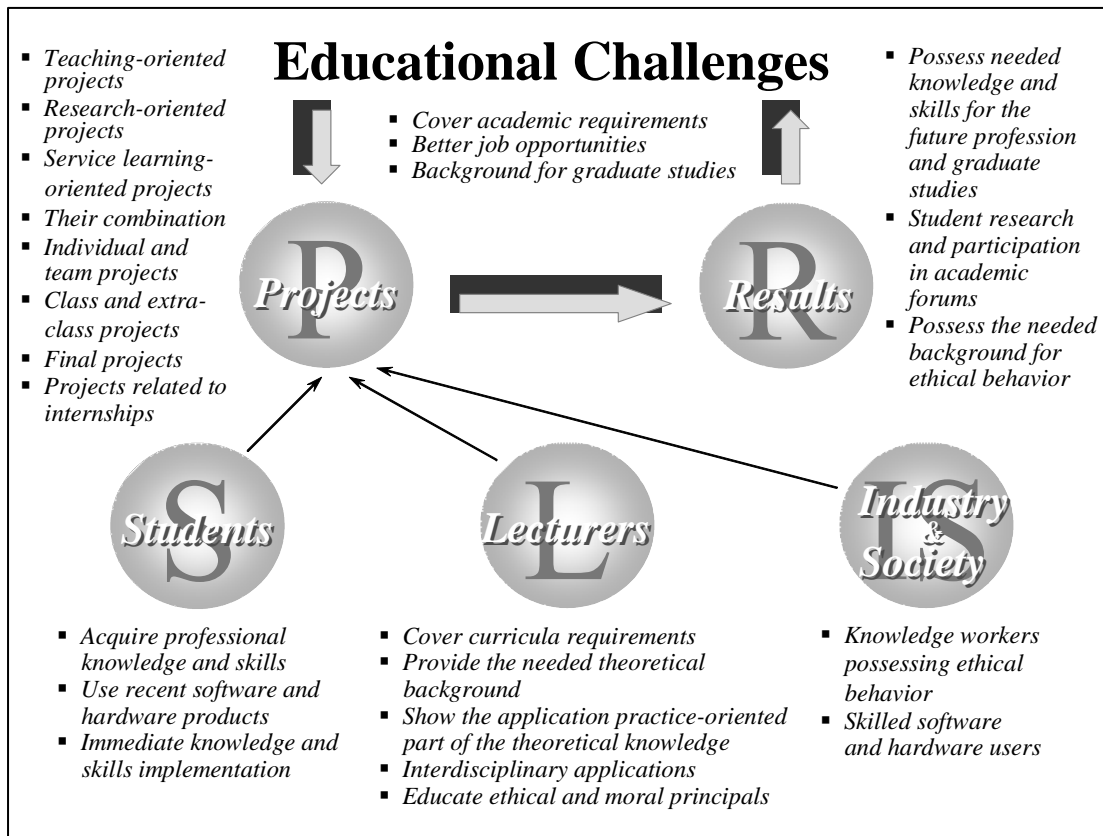


Figure 1. Aspects of the computing project development

The educational challenges in teaching computing disciplines could be successfully solved by introducing a rich diversity of projects offered as a part of different forms of academic work accomplished by students.

2. The Diversity of Projects

The most important aspects of the variety of computing project refer the project environment, types, topics, goals, participation, presentation, assessment, and ethical issues introduced in the project.

2.1. Projects and Their Academic Environment

To a great extent, the environment of the respective academic institution determines the characteristics of the computing projects. The respective curricula determine the type of the project, the corresponding requirements, and the period of time for its development. The author's impression is based on her experience gained at two different types of academic institutions: big national-level European universities on one side and US liberal arts colleges on the other side. The first thought would be that these two types of academic institutions are not comparable because of the difference in the number of the required courses for the respective major. However, both of them issue diplomas assigning the same legal rights to their graduates for the same academic degrees. How is it possible for graduates from liberal arts colleges to compete for jobs with students graduating from universities such as those mentioned above? The author's answer, based on her experiences from the last eight years of teaching at Elizabethtown College, has to do with the concept of the computing project and the way how these projects are created.

Obviously, university students develop a taste for research, not only in practice-oriented issues, but also in theoretical concepts related to the respective project area. Their projects are comprehensive and the complexity involved is high. Usually, the number of projects is reduced to one per course and some instructors do not even assign such projects in computing disciplines. The project results are due at the end of the semester or are accepted as a final examination or as a part of it. The final examination, extremely challenging and consisting of written and oral parts, plays the most important role in the course grading. Usually, the final project, or the so called B.S. Thesis, is developed during the last two semesters. It has a theoretical part and implementation part and shows the overall preparation of the student's ability in the respective professional area and is considered as a proof of the student's knowledge and skills gained at the university. Traditionally, when applying for a job, the graduate is invited to show the copy of the written report of the final project and to present in detail the work accomplished for it.

The teaching methods relevant to liberal arts colleges are different. From the beginning of each semester, college students are exposed to rigorous requirements, taking multiple quizzes and intermediate tests, and preparing a significant number of assignments. A major part of these assignments consists of the development of different projects for each course as class and out-of-class activity. The pressure related to the learning process is considerable, nearly exhausting at times. Students need to spend serious sustained effort in the preparation of projects as an extra-class activity. This method of teaching and continuous assessments of students' knowledge and skills does lead to a successful final result in most cases. The high level of competition in American society internally motivates students to learn how to work with different software products and to pursue the immediate implementation of their skills. Sometimes, these students do not realize the importance of theoretical academic preparation. However, the practical orientation of the projects covering different computing areas and the number of software products used in the preparation of these projects allow them to become valuable professionals, ready to accept different computing-oriented job proposals.

The variety of projects developed in a liberal arts college environment is described below. Concrete examples have been considered in different courses taught by the author such as Computer Science I and II, Information Systems, Introduction to Database Systems, Database Systems Development and Applications, Systems Analysis and Design, Web Programming, Introduction to Microcomputer Applications, Information Technology and Society, and Readings and Projects in Computer Science (CS) and Information Systems (ISs). Several basic criteria are considered in presenting the different types of projects.

2.2. Project Orientation

The variety of projects contains different project types.^[3, 4, 5, 8, 10] The project orientation determines the following types: teaching-oriented projects, research-oriented projects, service learning-oriented projects, and their combination.

Teaching-Oriented Projects

The first type of project is closely related to the material taught in a discipline and is a part of the syllabus of the course in the respective major. The forms could be different, such as writing essays or even an ethics code of conduct; analyzing case studies and presenting the results electronically; creating final solutions such as programs, drawings, diagrams, information systems, websites, etc.; and using software products or integrated packages and CASE tools. This type of project has been broadly explored by instructors.^[4, 5, 10] The feedback obtained from former students shows how useful these projects are and they should be considered as an important part of the students' academic work.

Research-Oriented Projects

The second type of projects, the research-oriented projects, is usually related to the undergraduate research. The role of the instructor is significant in this case and first, it consists of motivating the students to perform research activities. Students should understand the advantages of being involved in something that exceeds the expectations from their everyday academic work. The traditional form for senior student research is related to taking the course that requires the development of a senior/final project. However, there exist other extra-class research-oriented activities. Since 2002, the author of this paper organizes a seminar in ISs inviting students to share their knowledge in up-to-date computing topics and to present results obtained in their research projects. Usually, the seminar is attended by students who show a great interest in areas of computing and are looking to find an academic forum to present, discuss, and defend their ideas. Trying to be well prepared for the public presentation of the results of their research, students will do their best by checking multiple sources of information and reading an impressive amount of material about the respective topic. The role of the instructor in this case consists of offering appropriate advice, books, or professional scientific journals. Working on such projects, students come to realize what their real interests are. They develop a taste for similar work especially if they succeed in presenting their research results at an appropriate professional workshop or a conference. Sometimes, the preparation of such projects is associated with the decision made by students to enroll in a graduate academic program. Attending other students' presentations offers the opportunity not only to learn about new research areas but also to establish useful multidisciplinary relationships and to generate new ideas.

Today, an impressive number of conferences and workshops with IT orientation are organized. They attract the attention of faculty, students and IT-professionals. Such forums facilitate the exchange of information on the current theory, research, development, practice, and business applications of IT. They stimulate the growth of ideas and practical business solutions considered in the educational process in all academic disciplines. Introducing the most recent advances of information technology in the classroom today represents a valuable investment in the future. These events create the opportunity for faculty and business professionals to meet in the collaborative and innovative atmosphere and to establish fruitful relationships. They can also provide an excellent opportunity for students ready to share their research and practice-oriented results in the area of information technology and probably to meet with their future employers. Such a conference on IT in Education having international participation was organized by Elizabethtown College in September 2004 and sponsored by Dell, Addison-Wesley, McGraw-Hill, and other companies and organizations.^[12] All conference participants enjoyed the talks of the keynote speakers:

- *The Range of the IT Field and Where We All Fit In*, Gerald Engel, Leonhardt Professor of CS and Engineering, University of Connecticut, CT, and IEEE Computer Society 2005 President
- *Bioinformatics: A Recipe for Inter-Disciplinary Collaboration*, Paul Tymann, Associate Professor of CS at the Rochester Institute of Technology, NY, and ACM SIGCSE Symposium 2005 Program Co-Chair and ACM SIGCSE Symposium 2006 Co-Chair
- *Navigating NASA: How to Find Information in a Labyrinth of 2.5+ Million Web Pages?*, Dennis Christopher, Senior Support Scientist at the NASA Goddard Space Flight Center, MD
- *ENIAC: Dawn of the Age of Information*, Paul Shaffer, Curator of the ENIAC Museum at the University of Pennsylvania, PA.

Many Elizabethtown College students were involved in the conference organization. They met IT professionals representing different business organization. Some of the student papers passed successfully the blind reviewing process and were accepted for presentation at the conference and publication in the proceedings volume.^[12]

Service-Oriented Projects

In the liberal arts college environment, the most rewarding projects are those related to service activities which are the duty of students and faculty as members of the college community. These projects are related to multilateral aspects of the community needs and lead to real solutions.^[7] The usefulness of such projects leads to recognition expressed by the college community and this motivates students to develop new and better projects. Some of these projects are listed below:

- *Virtual Ad Board* – development of a database and a corresponding website for selling/buying used textbooks on-campus
- *Elizabethtown College and Handicapped Accessibility* – providing extensive information on campus accommodations for the disabled. The result was intended to provide a wide range of useful materials. A team project considering aspects of systems design and documentation was assigned to students attending the Systems Analysis and Design course. Students studied all of the buildings on campus to determine their accessibility. They created detailed floor plans of the buildings using appropriate software CASE tools to provide visual information concerning entrances, elevators, area parking, departments and offices in each building. In addition, the corresponding times and distances between buildings were estimated. Parts of the project were accomplished in class, but most of the work was done outside the classroom and later in the computer lab. The results from the team project have been used in the development of two other comprehensive student projects assigned in another course, Readings and Projects in CS and ISs, as individual projects. The first of them resulted in a website offering on-line disability information about campus buildings, facilities, and parking areas being developed. The second project created a corresponding IS containing the needed information and allowing its rapid processing. The impact of these projects was significant. They were reported as projects of the Campus Life Council. The results obtained were used in the virtual tour of the college campus for the new college website and have been implemented in the information system created for the purposes of the scheduling office. The data gathered was also found to be a very useful source of information by the Landscaping Committee and Facilities Management in the development of official campus maps. Current and prospective handicapped students can now obtain a booklet containing the needed information about handicapped accessibility on campus. The projects also offered appropriate opportunities to consider ethical issues relevant to Cyberethics and to discuss them with the students. Since 2003, four versions of this project have been developed because of the ongoing constructions on campus
- *Drinking and Driving* – development of a survey and performing a statistical analysis of the information collected from the anonymous answers with appropriate data visualization; a study accomplished for the Campus Life Council
- *Copyright Infringement at Elizabethtown College* – related to the activity of the Academic Integrity Committee
- *ITE'04 Conference Website and Information System* – the development of these software supported the organization of the Conference on IT in Education, September 18, 2004, Elizabethtown College, PA
- *Online Reporting of Faculty Grant Project Results* – development of different forms allowing the submission of online reports required by the Professional Development Committee
- *Nutrition Facts and the College Dining Room* – development of a database and a corresponding website, which facilitate the estimation of the nutrition content of the meals offered at the college dining room
- *Internship Information System* – development of a database and a corresponding website allowing the access to the database by business organizations offering internships, and students interested in these internships; accomplished as a part of an external grant awarded to Career Services

- *Etownian/WWEK/WKZT Website* – development of an interactive website to unify the information that is published, broadcasted, and/or shown through the three different media managed by Elizabethtown College students: the newspaper *Etownian*, the radio station, and the TV channel, and
- others.

The combination of the three types of projects is also possible and perhaps this is the most valuable type of project because of the incorporation of all the respective multilateral features. Such projects allow the broader understanding of the different aspect met in such cases and the better experience in finding real solutions.

2.3. Project Topics

The variety of topics considered in the student projects is rich. There are two basic groups of projects: theory-oriented and practice-oriented projects. The percentage for the first group is very low in liberal arts environment compared to the number of projects from the second group. Usually, the topic of the project is related to the project type:

- Class projects cover the material taught from the respective computing discipline
- Research projects are more comprehensive and reflect the knowledge and skills of the individual student and his or her interest in a specific computing area. Most of these projects represent senior projects developed at the end of the students' B.S. studies
- Service-learning reports consider topics that are suggested by community members and they are developed to satisfy real needs for informational processing.

In the last years, students developing projects show special interest in the following areas: information systems, database systems, database-driven Web programming, software engineering, electronic games, networking, security, and others. This could be explained by the recent interest of companies in e-commerce and m-commerce applications.

2.4. Project Goals

Each of the student projects has a very well determined goal. Three basic groups of goals could be mentioned:

- Educational goals related to the teaching process of the respective computing disciplines
- Providing students with a solid background needed for their future profession
- Preparing students for appropriate graduate studies.

Students demonstrate strong interest in developing projects by using recent software products currently used by many companies and organizations. This allows them to include items about professional knowledge and skills in their resumes and CVs that could be attractive to their future employers and could increase their chances to obtain the desired job.

There is a very special and important group of projects. These are the projects developed by students during internships. The real life offers the best lessons. Students are able to develop their professional abilities and to realize the value of their academic background. Usually, such projects become the entrance examination at the company or organization that considers hiring the student. This is also the first successful step in the professional career.^[9] Below, several examples of such projects developed by Elizabethtown College students are listed:

- *Giving a Small Business the Technological Edge* – development of an e-commerce solution (an IS and website) for a company selling water pools

- *Foreign Currency Processing* – development and implementation of an IS that processes the foreign currency information at one of the largest banks in Pennsylvania
- *CompuDent: Software for Dental Professionals* – an VBA database application implemented at the dental company offering the internship
- *Volleyball Corner* – e-commerce solution for a family store including the development of a database and corresponding database-driven website by using Microsoft SQL Server and ASP
- *Electronic Diary* – development of an IS and a corresponding database-driven website for medical purposes at the Hershey Medical Center, PA, and
- others.

2.5. Project Participation

The practice of teaching introduces different forms of collaboration when developing projects: collaboration between instructors and students as well as collaboration among students. Both approaches can be applied in project development^[3, 8]:

- *Individual Projects*. The author's impression is that most of the students, especially those who have good to outstanding performance in the subject taught, prefer individual projects. Senior projects assigned to graduating students are nearly always individual projects. In rare cases, they could be joint projects.
- *Team Projects*. The individualistic mode of social behavior found in certain nations calls for the use of team projects to foster an appreciation of group work, especially in the area of computing. The valuable group experience gained has long been recognized and college instructors also use this type of project to teach principles related to computer ethics.^[8] Usually, instructors apply two types of grading for such a project: grading the individual student's results and grading the group results. Students who need more help can benefit from working in this way and better overall performance of class work can be achieved.

2.6. Project Presentation

Students use different presentation techniques and tools to report and show the results obtained from the project development. In all cases, an electronic copy of the project results is required that is developed by using different specialized software products and commonly used application programs. The author of this paper invites her students to submit a brief abstract. This is useful for the precise formulation of the main problem solved, the description of the methods used for the problem solving, the decision making about the software products used, and the student's individual contribution. Sometimes, electronic presentations are developed or students demonstrate how to operate with the software product developed by them. An important requirement in the development of a senior project is the presentation of the written report having a layout similar to a M.S or Ph.D. Thesis. Students learn how to present their results by providing the right description, analysis, and visualization of the report content. This also adds an aesthetical taste to the project presentation and prepares students for writing technical reports or scientific papers related to their future job or possible graduate theses.

A very interesting experience for the author was the event of the final projects presentation at the University of Limerick in Ireland. Two days are scheduled for the graduates from all majors, all at the same time. The first day is for the academic audience. The computing students offer electronic presentations describing the theoretical concept of the project and the practical results achieved. All students prepare posters and offer a demonstration of their project results. The second day is spent only in the computer lab. The guests are representatives of different companies interested in hiring computing professionals. In this way, the final project presentation doubles as a job fair and nearly all students obtain invitations for job interviews.

2.7. Project Assessment

The author of this paper has advised and supervised a variety of class projects. She has also collaborated with her students in the development of undergraduate research projects. Different experiments relevant to the assessment of computing projects have been accomplished.^[1] The goal was to implement methods that give a better precision of the assessment measures and encourage the students' interest in such a creative activity. The theory of the assessment discusses well-researched approaches considering the student intelligence, sensory acuity, achievement with multiple-skill devices, reading, mathematics, oral language, written language, perceptual-motor skills, problem behavior, adaptive behavior, etc.^[1, 2, 6] The following additional assessment aspects, specific for computing projects, could also be mentioned:

- variety of software products used
- data collection and data organization
- introduction of referential and entity integrity of the data in consideration
- consistency of the data used and accuracy and correctness of the project results
- multidisciplinary relationships
- type of interface proposed for users
- layout of the generated results
- accompanying documentation
- responsibilities and collaboration of team members
- submission of the completed project in different ways: hard copy, files stored on respective servers, incorporation of online features, database-driven webpages, etc.
- development of a corresponding electronic presentation
- initiating an appropriate discussion during the presentation of the project
- hardware compatibility
- possibility of real implementations, and
- others.

The assessment aspects listed below and accompanying the traditional instructor's evaluation are also important:

- peer-to-peer student evaluation of projects
- possibility of project's implementation in college community activities, or service-learning orientation of projects
- ethical issues introduced in the project
- project value that could lead to the presentation of the project results at appropriate academic forums.

The milestones of the assessment process related to the assessment project plan are incorporated in the project assignment. This allows students to be aware of the expectations related to the respective project. Their critical thinking during the entire period spent for the project development will increase the quality of the results.

2.8. Ethical Issues Related to Projects

Focusing the attention of students on the ethical aspects of cyberspace is important because the nature of their relationships affects large groups of users and has a significant influence on their professional and personal interests. Two different approaches of introducing ethical issues can be applied. The first one consists of introducing ethics as a part of the teaching material in several computing courses. The second approach implements miscellaneous forms of extra class activities for the same reason. The second

approach is especially valuable when developing a variety of student projects through blending ethical aspects with specific computing topics. Many of the computing projects developed by Elizabethtown College students discuss ethical issues and moral principals in their projects.^[11] Two examples of such projects are:

- *The C2K Agreement Website* – development of a database-driven website for the needs of the national project for the restoration of the Chesapeake Bay;
- *Practical Applications on Information Technology* – development of a database-driven website for the needs of the US companies issuing approvals to builders related to the existence of animals in danger in the soil of the construction lots.

3. Conclusions

The diversity in the development of computing projects allows students to obtain knowledge and skills in using a variety of commercial software products and a strong background in industry-oriented professional activities. With these skills, they will be prepared for the highly competitive world outside of their academic institution and probably, for pursuing graduate studies. At the same time, the service-learning orientation of their projects makes the connection to the college community stronger and is a connection that they can preserve for the rest of their lives. Studying at a liberal arts college is an option preferred by many young people. They appreciate the opportunity to graduate in a friendly environment as valuable professionals in their area of specialized study and as members of society possessing ethical behavior and a good understanding of a broad variety of academic disciplines.

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