FRONESIS - THE THIRD DIMENSION OF KNOWLEDGE, LEARNING, AND EVALUATION

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Abstract *— The situation today is quite different from what we have been used to. The globalization and the availability and use of Internet have changed our view of knowledge, learning, and examination. We will here, however, use a very old knowledge model in our presentation, that of Aristotle with his three components: Episteme, Techne, and Fronesis.*

Episteme covers the most common view of academic knowledge, the understanding that can be achieved by reading books. Episteme is the declarative knowledge that can easily be transferred from the teacher or author to the student.

Techne can be viewed as the technical skills like ability to ride a bike. This capability can be achieved by learning from a master and imitate the behavior. Techne has a strong tradition in engineering education. Lab exercises are aiming at developing such skills.

Episteme and Techne have been sufficient to capture the essentials of engineering education. Today, however, the ability to find answers to ***new*** *questions and solutions to* ***new*** *problems is more important than the ability to remember contents from textbooks. Fronesis, is the "political knowledge", that is the ability to understand and interpret the situation at hand and decide about appropriate actions. What is new in our time is that the general situation is very different from what the teacher has experienced, and from what previous generations have met.*

We are claiming that Fronesis today is the most important dimension of knowledge, and in our paper we will present how we have designed computer-programming courses to take this into account. Traditional examination can check the Episteme capability and Techne can be checked by practical demonstration: playing the piano, building an electronic device, etc. Examination of Fronesis needs special consideration, and we are testing the Portfolio approach introduced at Harvard University and used successfully in many countries.

Index Terms — Fronesis, team learning, project organization, portfolio.

INTRODUCTION

Today it is a rather widely accepted view that the capabilities required from us, as engineers as well as as citizens, are quite different from what has been the case in the past. The globalization means that we must have a better understanding of international relations and other cultures. We must be able to be integrated contributors in multi-ethnic and multi-lingual groups and communities. In industry it is no longer sufficient to be the best one locally in the city or in the country. International trade makes it necessary to be competitive globally.

Fast development makes it necessary to keep in pace with the new technology. You can't rely upon models, methods or tools you learned about when you were a student. A continuous update is needed all the time. A study of some typical development projects within Ericsson [1] shows that even in rather short projects, 8-12 months, the traditional basic project model: first analysis, then requirement specification, then design, then implementation, etc., was completely useless. About one third of the initial requirements, defined after careful screening, were cancelled during the project, and about one third of the functions required and implemented at delivery time were not even considered when the project started. So, the conclusion from this is that the development teams must themselves be aware of and understand what is going on in the environment: new technology, competitor moves, etc., and react themselves. There is not time available for a hand-over from those who understand to those who are doing. The doers must be the understanders themselves.

In the past it was important to remember facts. We were taught at school the names of nations, the sizes and names of their capitals, the major components of their export and import etc. The idea was that such declarative knowledge was stable over our lifetime. Today there are two good reasons to question this model [2]. Firstly, we need not rely upon our memory for this information as such facts are almost always available, over the computer networks and available in our laptops and cellular connected palmtops everywhere. Secondly, the rate of change is such that this declarative knowledge, inherited from teachers and parents, will have a lifetime much shorter than our own. It is a better

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model to get new fresh information when needed, than to recall old memorized information.

Another development in our time is towards complexity. The systems to be developed by our engineers in industry are more and more complex. More functions are integrated into the same system, and the operational environment is also becoming increasingly complex. To understand all the different aspects experience and knowledge from several persons, experts from several areas, will be needed. The capability to answer questions and to define problems is supplied by the collected team in interaction, and not by the individual team members. From the engineer or expert, a capability to communicate and to understand totality is required. Team understanding capability [3] is one of the major successes factors in the development of complex technical systems.

The general basic model for our educational system is to bring to our students the accumulated knowledge and experience from previous generations. However, when the major part of relevant knowledge and information is created during our own lifetime, this basic model fails. Today it is questionable whether our students are getting the major part of their knowledge, understanding, and capability from their time at school in classroom or library, or from their leisure time when travelling or with friends, computers and videos. What is needed in our time is an ability to learn and understand *new* things, and an ability to define and solve *new* problems. The most important question to our educational system is: How can we best support our students in the development of such skills?

In our work we have based our thinking to a great deal upon ideas from ancient Athens, from Aristotle and Socrates. Aristotle discussed three basic components of knowledge: *episteme*, *techne*, and *fronesis* [4]. *Episteme*, in short, is the traditional declarative knowledge, what we have been teaching and examining in our school and university systems. Lectures, textbooks, oral and written examinations are the instruments used. *Techne* is the practical skill or capability. In engineering we have our lab exercises or courses. In physics or chemistry the original tradition has been to have the student repeat classical experiments and present observations in a report. In real work life the way to develop *techne* has been by means of the master-apprentice model. The student, the apprentice, observes the master and tries to understand the objective as well as to imitate and copy the behavior. A combination of *episteme* and *techne* has in the past been a successful basic model for engineering education.

Today, however, the third component, *fronesis*, will also be required. *Fronesis* is about understanding and interpreting the situation at hand. As this situation, normally, will be different from the previous situations the student can read about in textbooks or the situations where the student has observed the master, a new analysis and interpretation of the present situation will be needed. The capability to understand and interpret the current situation is just *fronesis*. ”Political knowledge”, where a broad experience and understanding is required, and general ”wisdom” are very helpful. Political knowledge, as discussed by Aristotle [4], is the ability to interpret the situation and understand what the effect will be from different actions or interventions. Wisdom is about understanding good and bad, right and wrong, and thus by necessity related to values and ethics [5]. As we know from the past how to handle *episteme* and *techne*, but as we have very little experience from focusing on *fronesis* in our educational system, our major interest and the theme for this paper are the investigation of mechanisms for the promotion and support for the development of *fronesis*.

PROGRAMMING COURSES AT THE UNIVERSITY LEVEL

There is a long tradition in engineering education to combine theoretical studies and practical lab exercises, and such combinations have been organized in different ways during different periods and at different places.

Different Learning Approaches

Design and development projects of substantial size have been common in engineering programs. At Aalborg University, Denmark, about 50% of the courses have been organized as projects and the rest as conventional courses since the start in the early seventies [6]. The idea has been that a training environment in these projects similar to the working environment for the engineers in the future would be appropriate. A successful project result has been a requirement for a ”pass”. In general a written project report from the group has also been required. The overall experience from this fifty-fifty combination of projects and regular courses is positive. The project makes the students in general more motivated and enables a more holistic approach than you normally have in disciplinary courses

Problem Based Learning, PBL, is another approach to achieve holistic views and integration over the disciplines. From education in medicine and health care [7] PBL has also propagated into engineering programs. In medicine however, it has mainly been used for motivating the students and to help them to define their individual learning needs. The real learning in the next phase has been rather traditional and based on the assumption that the material to penetrate has been available, in general as textbooks and journals, in the library.

We claim that the situation in engineering is different [8]-[10]. In engineering the development team is all the time confronted to new problems and new questions. The team must by itself be able to understand what to do and why in the new situation and can’t rely upon solutions and answers under other conditions in the past. What is needed is simply the *fronesis* capability. This does not mean that the traditional *episteme* and *techne* components are irrelevant. On the contrary! Once the problems are defined, the problems as such are by no means simpler than the engineering problems in the past. The difference is that the definition of the problem is part (often a major part) of the problem, and also that the definition of the problem is dynamic. It is very likely to change considerably during the course of the project.

Our Hypothesis and Curriculum Design

As we believe that the team learning aspect is very important we have used the student group as a basic instrument for the learning. As we want to emphasize the ability to define the problems and questions and not only to find the solutions and answers, we have decided to leave to the students to understand what to do and how to organize the work. The course we have used in our experiment, now for the third year, is a *Programming Project* course for a group of 60-70 second year engineering students in a four and a half year electronic design program. The course runs from early November until mid March. The students have two more courses in parallel and the size of our course is seven points (one point equals one week of full time effort). The technical content of the Programming Project course is computer networking and object oriented architectures, and we have also a requirement on graphical user interface with some animation and some sound involved.

So, in order to introduce the problem definition component into the course and to build upon team learning, we have done the following. The whole group of 60-70 students has been given the task to develop a distributed software system based upon a shared information server, and client programs. The definition of the set of functions for each subsystem or client has been left to the students. We have prescribed that the implementation shall be done in teams of five to seven students. The first step is to define an initial version of the overall functionality for the system, and the second step is to decompose the total system into ten to eleven subsystems, each to be implemented by one of the teams. At the end all subsystems should be integrated to one running distributed system having the functionality and the performance defined.

The first year the total task was control and simulation of elevator systems. There were floor clients, inside elevator clients, operator console, supervisor clients, etc., in addition to a central data and simulation server. The second year the task was to implement a simulated public transport system in a city. There were railway station clients, train clients, traffic control clients, street clients, etc. in a computer game-like fashion. During the year 2001 the task was to develop a simulated hotel with manager clients, reception clients, casino clients, bar clients, gym clients, gift shop clients, restaurant clients, lift clients, room clients, a shared information/event server, and a web interface to the whole system. The system implemented is made available over Internet.

The organizational form of the course is an introductory lecture where the objective and the general philosophy are presented together with the suggested theme of the year; this year the simulated hotel. We have formal project meetings with teacher participation with each group once a week. Agenda and minutes for the meetings for all groups are made available via the homepage of the group. Dates for subsystem tests, integration test, and acceptance test, are scheduled such that the implementation work and corrections should be finished one week before the end of the period.

Initially, before the students have been able to develop any shared understanding of what to do and why, the course leader may act as a project leader. Very soon, however, the students will be in control, and the role of the course leader will become more like a mentor. Sometimes he/she has to play the role of the customer to give feedback on ideas about functionality and maybe also about system structure. Our own view of the task of the course leader is to design and define the context or the situation the students are put into. If this design is successful, only minor control and guidance will be needed during the project.

It is our strong belief that it is important to leave the responsibility and the control to the students, to let them be driven mainly by their own curiosity and creativity, and not just trained to solve predefined well-structured problems.

Until now the requirement for ”pass” has been defined as ”each student shall by himself or herself have the understanding and skills required for the implementation of a similar system”, and the instruction to the student is to ”convince the examiner that the requirement is met”. There are two hours available for examination for each group of six students, and first the students are presenting what they have done, how they have done it, and why they have taken the design decisions they have. This may take 45 minutes, and sometimes the examiner will be convinced after this; we have a rather good view from our weekly project meetings of what each student has done and learned. When we in some cases are not convinced after 45 minutes that every student in the group has sufficient understanding, we have 75 more minutes available for discussion with the remaining students.

Experience and conclusions

Our general experience from the course is that most of the students are much more involved and ambitious than is normally the case in a conventional course. Most of them learn much more and spend much more time on the course than we could possibly require. From the teacher side we are quite convinced that we are promoting the development of the *fronesis* capability, the ability to understand the current situation and the ability to act and reflect upon the actions. From inquiries we have some feedback from the students, but the interpretation of the response is not straightforward. About one third are satisfied saying things like ”the first time we really learned something”. However, about the same number are critical: ”it must be the responsibility of the teachers to plan and organize the course and to supply us with the course material to study”.

It is our belief that the experience is valuable and relevant also for the critical students, but we must confess it is just a belief. We have a hypothesis that the portfolio concept, presented in the next section, in the future will help us also with the critical students.

THE PORTFOLIO CONCEPT

The *fronesis* capability to understand the current situation and decide about appropriate actions is not very different from some concepts of our time. In *e.g.* ”action learning”, ”reflective learning”, and ”authentic learning” there is often a component of understanding the context and the effect of different actions. The portfolio concept, originally used in arts for a collection of previous work, has evolved to a more general instrument for the assessment of progress in different areas. If goal-setting and progress reports in general are included in the collection in the portfolio, you have something that can be used also to capture the *fronesis* improvements.

After the portfolio was introduced as an assessment instrument by the Harvard Project Zero [10] in the sixties, the concept has been widely used in primary and secondary schools in many countries. In our case we have by pure coincidence been able to combine experience from computer science education at the university level and findings from student assessment and staff development in primary and secondary schools in Sweden.

A tool for authentic assessment

Learning is a development over time, starting with the goal setting. The development itself consists of activities, experiences, analysis, products, and assessments. Together with the teacher the student decides whether he or she has reached the goal as planned. By means of a portfolio, you can document important steps in your learning and make the progress visible. The portfolio will encourage reflection over the process and thus enhance learning. Our view of learning and understanding is based upon the interaction between action and reflection, and that real learning will result in a change of behavior.

Vavrus [11] defined portfolios as ”*a systematic and organized collection of evidence used by the teacher and student to monitor growth of the student´s knowledge, skills and attitude. The portfolio can provide an authentic and meaningful documentation of a student´s abilities, provided it contains the artifacts of the progress, as well as his/her reflections on both his/her learning and the artifacts chosen*”.

As described in the previous section, the society of today has the need for new thinking and new abilities, and teaching and learning have to be more flexible. The learning process tends to become more and more adapted to the individual student and to take place not only at school, but all the day round at different places. One of the major tasks for the educational system will be to help the students to deal with this new situation and to give each student tools to work with his/her learning and development.

As teachers we have had much experience of how difficult it is to motivate students to give that little extra effort and to see the idea of making any effort at all. Very often we have wondered what happened with the curious happy children when they grew up, and were transformed into tired, uninspired teenagers. When we started working with the portfolio, we found that this tool enables us to help the students observe their own learning and support them in their own goal-setting. That work revives their curiosity and willingness to learn. It also gave us as teachers a lot of information useful when supporting their learning.

The purpose, as described above, with the use of the portfolio is:

1. to make learning and development visible,
2. to make clear what needs and goals the student has with his/her work
3. to make the student responsible for his/her learning, and
4. to make the students and the teachers conscious of what support is needed. [12]

A problem to deal with, as described in the model for group learning above, is how to make visible to the teacher that learning has taken place [13]. This has frustrated professional educators as well as others during the last half of the 20th century, and has resulted in using standardized testing more and more. This dependence on exam results has led to tests driving classroom instruction within the school. The goal becomes excelling on the test. Individual student learning rests on how well he or she performs on a test, rather than how much the student really knows and how the student might demonstrate the school content in the most authentic manner.

Traditional assessment practices lack sensitivity to the individual progress that educators expect from students and do not promote encouragement of lifelong skill acquisition. Furthermore, much of the testing prevents students from thoughtful reflection and evaluation of their own work.

We claim that in our time we must support the development of the *fronesis* capability, the wisdom itself. This support must influence the teaching methods as well as the approach to assessment. We need new assessment tools that also support the self-assessment by the student. In this repertoire you can see logs, records, observational notes, checklists, interviews, performance assessment and much more, all incorporated in a *portfolio.* When you start to build a portfolio, you start to collect artifacts that show who you are as a person, how you think about things, and what interests and ideas you have. In the portfolio it is also natural to put the goals the students should aim at in different subjects, and what is a possible performance and what is unacceptable. Possible portfolio artifacts are work samples, letters, drawings, photos, tapes, videos, logs and collaborative projects, and assessments from peers. The *most desired outcome* of the portfolio construction is to have students take responsibility for their own learning and to develop a desire to do their best. It is essential to have reflective statements within the portfolio. Students need to develop *metacognition*, the ability to think about their thinking. ”Thinking about thinking begets thinking”. The portfolio concept is also supporting authentic assessment.

In the ”smart Schools” model [14] there is a set of seven guidelines for good education that is based on two guiding principles

1. learning is a consequence of thinking - and good thinking is learnable by all students
2. learning should include deep understanding, which involves the flexible active use of knowledge.

Experiences from use of portfolio

A reflective portfolio for students has been used since the start of Project Zero at Harvard Graduate School of Education. From July 2000 Steve Seidel, a leading researcher about portfolio, has conducted the project. Some parts of the project, Arts Propel and Apple, have focused on assessment via portfolio. Eleven schools in Massachusetts have participated in a co-operation between Project Zero, the State government and the schools.

For example, Cambridgeport School makes their students sit for an exam with their portfolios as a tool. They present their work and their learning for a jury with a parent, a couple of teachers, the principal, and some people from businesses in the neighborhood. The students prepare for their exam for a long time, and they have to present work from four different areas, Mathematics, Science, Social science, and a written presentation of themselves. The schools in the project show good results in many ways.

The idea of the portfolio as an assessment tool is also spread around the world and is tried in many countries, for example New Zealand, Australia, Canada, and Sweden. We have ourselves been teaching High School students and used portfolio developed from process writing methods [15]. When we started to use the process writing method, we soon found that the expectations from the students were rising. They learned how to find out how they could work in a more efficient way, what they already knew, and what they wanted to learn when we started a new task. All students took an active part in their work, and for us as teachers it was a great opportunity to learn about how the students are learning. We developed some sort of portfolio and found that we got a much better outcome than before.

In New Zealand, where many schools have worked with portfolio for about eight to ten years, the teachers feel that it has made a big difference in the way students think about what they learn. They definitely take more responsibility for their work, and reflect in a very complex way about their learning. Students think they learn more, and parents think they get a much better information from school.

For staff development we have used a portfolio, too. In the City of Katrineholm, Sweden, we have 17 principals. They get education via the School District, and they are using their portfolios to collect artifacts that show their learning and their development as leaders. They reflect about their development and discuss their portfolios in a yearly meeting with the Superintendent in the district. In their portfolios they also make plans for their future learning, set goals, and make assessments.

We think that portfolio is a very useful method for self-assessment and self-reflection. ”*I tell you that this is the greatest good for human being, to engage every day in arguments about virtue and the other things you have heard me talk about, examining both myself and others, and if I tell you that the unexamined life is not worth living for a human being, you will be even less likely to believe what I am saying*” [16].

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CONCLUSIONS AND FUTURE WORK

Only fragments of the portfolio concept have been used in our assessment and examination at Campus Norrköping, Linköping University, so far. The preliminary experience, however, is very promising, and we intend to use portfolio as the main instrument for next year. The author B. Lennartsson has an affiliation also with Luleå University of Technology, Sweden, and there the use of portfolios has gained interest among the Ph.D. students. Our plan is to use the concept more systematically and evaluate the result more carefully in the different arenas. Currently we can se no alternative to the portfolio when managing the development of the *fronesis* capability.

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