A PROPOSAL TO BROADEN THE CDIO SELF-EVALUATION MODEL

Juha Kontio
School of Telecommunication and e-Business
Turku University of Applied Sciences

Abstract
The quality of education is a very relevant topic in the field of education. The quality should also be measured in some reasonable way. The CDIO initiative provides a self-evaluation model to analyze the CDIO adoption level. The adoption level is analysed in relation to 12 standards. The evaluation should be documented in detail to make sure that the chain from evaluation to improvements is valid.

The CDIO evaluation model is very simple and easy to use and learn. However, the evaluation results are very simplified. Therefore, this paper proposes how the original evaluation model can be broadened to give more power to the analysis. The proposed extension is a model describing an innovation process in organizations.

Furthermore, this paper shows an example of one evaluation round at the Turku University of Applied Sciences. The examples show that the evaluation functions quite well. The extended evaluation model provided valuable information for focusing on the development actions.

Finally, even though CDIO initiative is not a quality assurance tool, it certainly is a package that has a positive influence on the quality of higher education. Hopefully the proposed extension can support this continuous improvement process.

Keywords: Program evaluation, Innovation process, CDIO, Diffusion of innovations

Introduction

The quality of education is a very relevant topic in higher education at the moment. There are numerous reports and documents discussing out the quality of education at higher education institutes (HEI). One of the main documents in Europe is the Lisbon strategy. On the basis of this, the European Ministers of Education agreed on common objectives for education and training in Europe in 2010 [1]. The first objective was "Increasing the quality and effectiveness of education and training systems in the European Union" [1]. A group of experts published a mid-term report of achieving the objectives set in Lisbon strategy. One of the observations was that education and training must be improved so that enough young people are graduating with the appropriate skills to obtain jobs [2]. In Finland the Ministry of Education has defined that one of the major challenges in the next ten years is answering ever growing skill requirements with improved quality of education [3]. The Rectors Conference of Finnish Universities of Applied Sciences has made a similar stand on this: A crucial success factor is an internationally competitive, high quality educational system [4]. The

British Department for Education and Skills wrote in the Future of Higher Education report in the same way: As higher education is increased, we must not compromise on quality, and we must make sure that education really matches the needs of the economy [5]. Furthermore, the Finnish Innovation Fund writes that the cornerstones of successful innovation activity are top-quality education, research and development evolving from current needs [6].

It is of no surprise that the Ministry of Education has stated that the focus of development actions should clearly be at validating the quality and impressiveness of education [7]. Earlier the development group of technology education presented many structural reforms to improve the quality and competitiveness of education [8]. It has become increasingly important to continuously improve methods, processes and organizations relating to the quality of education and research [3]. Lately, The Rectors Conference of Finnish Universities of Applied Sciences has stated that it is evident that the structures, contents and implementation methods of higher education degrees have to be renewed in order to meet the challenges set by the changing environment [4]. While making changes in the educational system the importance of quality assurance and quality management raises both at national and international level. Therefore we should focus increasingly on continuous improve of the quality of education and quality assurance. [3] The confidence to national level of higher education is not enough rather higher education must be understandable and trustworthy internationally as well [9].

The Finnish Higher Education Evaluation Council is responsible for evaluating the quality of education and other activities in both Universities and Universities of Applied Sciences. It is independent of government steering and there are no direct links with funding. [10] However, European higher education operates in global markets and it has become necessary to show the quality of education and degrees. Still, HEIs in Finland are themselves responsible for their quality of education and other operations. [9] The CDIO initiative [11] is an innovative educational framework that offers 12 standards that guide the education development process in the university. These standards do not take the role of quality assurance, but they offer a framework that can be used in improving the quality of the education.

The CDIO initiative contains a self-evaluation model where a university can evaluate its own performance in relation to 12 standards with a numeric scale from 0 to 4. The numeric ratings of each standard can be summarized and the final sum can be anything between 0 and 48, but what does this sum actually tell? This sum does not directly tell anything about the quality of the education. However, the repetition of this analysis will give longitudinal information about the improvement results of the taken development actions.

While the CDIO initiative can be defined as an innovation, the process leading to the implementation of the CDIO in a university can be understood as an innovation process. In this paper, we can compare the CDIO self-evaluation model with the innovation process described in the diffusion of innovations' theory [12]. The CDIO self-evaluation scale (0-4) with its' explanations describes pretty much the same way the innovation process and the level of adoption in a university as the diffusion of innovations theory does. The aim of this study is to join the numeric analysis of the CDIO adoption level with the diffusion of the innovations' model. Our goal is to propose a model that broadens the analysis of the CDIO adoption level in the university. Instead of having just a number describing the adoption level a more descriptive analysis is developed based on the diffusion of the innovations model. In addition, we will propose how the analysis could be applied when the university defines future development actions to improve the quality of education.

The structure of this paper is following. The next two sections the CDIO self-evaluation model and Innovation process in an organization are presented. After these sections the proposal for broadening the model is presented. Then the model is tested and discussed. Finally, the conclusions of this study are presented.

Research

Design and methods

This research proposes a broadening of the CDIO self-evaluation model to increase the information from the evaluation. The main idea is to provide more support for the development of education. The research question is "How the CDIO Self-Evaluation Model can be enlarged?". The focus is especially in connecting the CDIO self-evaluation model with the innovation process in organizations model presented in the diffusion of innovations theory [12].

The main method in this study is theory building and testing. The proposed model is partly tested with the case organization.

CDIO Self-Evaluation Model

The CDIO initiative is an innovative educational framework that offers 12 standards that guide the education development process in a university. The standards define the distinguishing features of a CDIO program and serve as guidelines for educational program reform and evaluation. [11] Gray defined program evaluation as a process for judging the overall effectiveness of a program based on evidence of progress toward attaining its goals [13]. However, the CDIO standards do not take the role of quality assurance, but they offer a framework that can be used in improving the quality of the education continuously [11] . The CDIO program evaluation model shows the basic process and rationale for the evaluation (Figure 1).

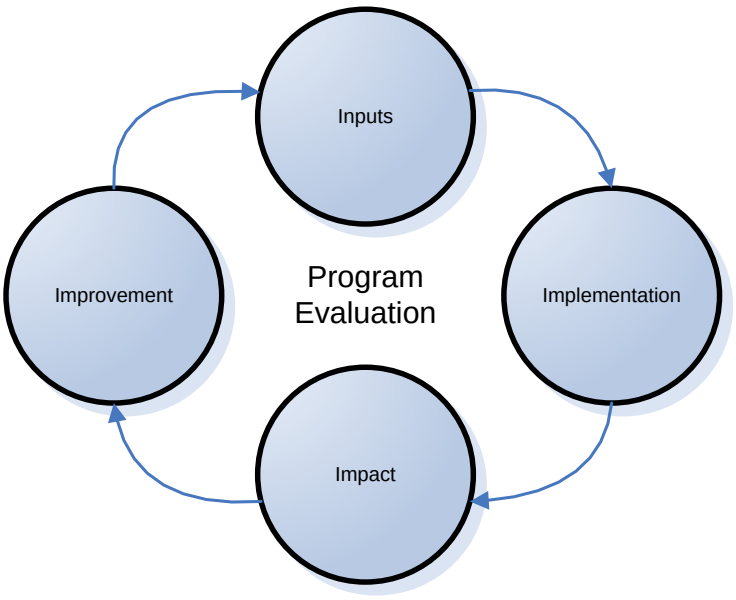

Figure 1. The CDIO Program Evaluation Model [11].

As described in the CDIO website program evaluation consist of a) Inputs including program purposes, resources, and planned activities, b) Implementation that refers to the actual program activities c) Impact that gathers evidence about program outcomes and d) Improvement emphasizing the use of results for continuous program improvement.

Term standard-based program evaluation is used to describe the evaluation approach used with CDIO programs [13]. This means that a university can evaluate its own performance in relation to 12 standards with a numeric scale from 0 to 4. Level 0 means that the university has no initial program-level plan or pilot implementation with the standard in question. Level 4 means that the university has complete and adopted program-level plan and comprehensive implementation at course and program levels, with continuous improvement processes in place. Besides the numeric ratings, the evidence describing the rating of each standard should be described [13]. This requires that there are a variety of methods to gather data for the evaluation. Furthermore there must be a process to adequately document the analysis of the data and the decision made for continuous improvement.

The numeric ratings of each standard can be summarized resulting in a sum between 0 and 48. A few examples of the summarized results and continuous improvement of some universities can be looked at the basic CDIO: Ready to Engineer presentation [11]. The final sum shows how far the university is in the CDIO standards scale, but any other information is not connected there. However, the repetition of this analysis will give information about the results of the taken development actions. Still, it is just a number that does not have any additional information on it.

Diffusion of Innovations

Rogers defines diffusion as a process by which an innovation is communicated through certain channels over time to the members of a social system. An innovation is an idea, practice or object that is perceived as new by an individual or other unit of adoption. [12] The CDIO initiative obviously fits in the definition of an innovation.

While the CDIO initiative can be defined as an innovation, the process leading to the implementation of the CDIO in a university can be understood as an innovation process. The innovation process in an organization is broadly divided in two parts: Initiation and Implementation (Figure 2). The innovation process was described in [14] originally. The initiation sub-process is divided into two stages. The agenda-setting stage occurs when a general organizational problem is identified that creates a perceived need for an innovation. The term ‘performance gap’ is used in describing this kind of problem and it is defined as the discrepancy between an organization’s expectations and its actual performance. In the matching stage the organization identifies a problem and opts for an innovation to solve it. Redefining/restructuring occurs when the innovation is re-invented for the needs of the organization and it prepares for the innovation. In the clarifying stage the meaning of the new idea gradually becomes clearer to the organization’s stakeholders. Finally, routinizing the innovation ensures that it becomes part of regular activities in the organization and it loses its separate identity. [12]

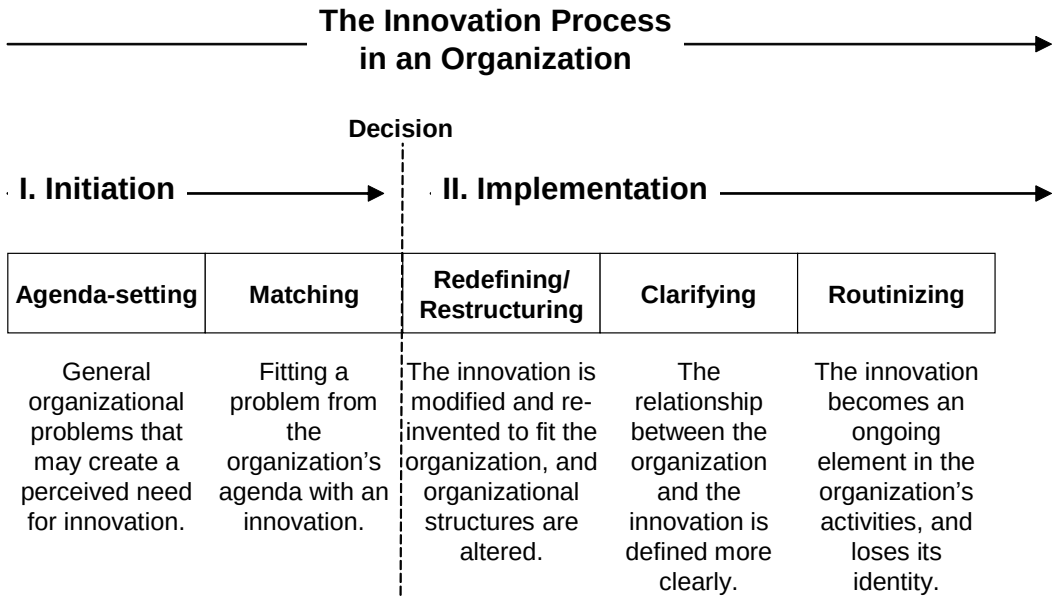

Figure 2. The innovation process in organizations [12].

Organizations considering innovations go through the innovation-decision processes. There are three different types of innovation-decisions in organizations. First, optional innovation decisions are decisions that an individual makes independently of the decisions by other members of a system. Second, collective innovation-decisions are choices that are made by consensus among the members of the system. Third, authority innovation decisions are decisions that are made by a relative few individuals in a system who possess certain status or position. [12]

According to Rogers (2003) there are five main attributes that influence adoption of these innovations (see Table 1). The minus sign after 'Complexity' indicates that it has a negative influence on the adoption of the innovations.

Table 1. The attributes of innovations influencing adoption [12].

Attribute	Description
Relative advantage	The degree to which an innovation is perceived as being better than its precursor.
Compatibility	The degree to which an innovation is perceived as being consistent with the existing values, needs, and past experiences of potential adopters.
Complexity (-)	The degree to which an innovation is perceived as being difficult to use. This is negatively related to the adoption rate of the innovation.
Observability	The degree to which the results of an innovation are observable to others.
Trialability	The degree to which an innovation may be experimented with before adoption.

Test environment

The proposed model is partly tested at the School of Telecommunication and e-Business at

the Turku University of Applied Sciences. The Turku University of Applied Sciences is one of the largest of its kind in Finland with almost 9000 students and 33 Degree Programs. The TUAS is organized in six schools that promote multidisciplinary learning. The School of Telecommunication and e-Business (TEB) represents four different fields of education: technology, business, natural sciences and culture. Our main goal is to work in close co-operation with our region and to answer the requirements of the working life. Our education and our research and development initiatives focus on applying knowledge in state-of-art problems not forgetting creation and testing of new applications and technologies. The School of Telecommunication and e-Business operates in two cities and has eight Degree Programs. Five of the programs are located in Turku and the remaining three in Salo. We educate both Bachelors of Engineering and Bachelors of Business Administration. In addition, we will start our first Master of Engineering program (Technology Competence Management) autumn 2008. The Bachelor of Engineering is a four-year degree with 240 ECTS and Bachelor of Business Administration is a three and a half year degree with 210 ECTS. The school has approximately 1500 students of which roughly 550 study in Salo campus and 950 in Turku. The number of our own staff is ca. 100 consisting of managers, lecturers and other experts.

We have been members of CDIO initiative since November 2007, but we have been working with CDIO since summer 2006. At September 2006 the director of education made the evaluation of the School individually (Table 2). It is noteworthy that CDIO is an educational framework for all our programs not only for our engineering programs.

Table 2. School evaluation at September 2006

Standard	Rating
1: CDIO as Context*	0,0
2: CDIO Syllabus Outcomes*	2,0
3: Integrated Curriculum*	2,0
4: Introduction to Engineering	1,0
5: Design-Build Experiences*	2,0
6: CDIO Workspaces	2,0
7: Integrated Learning Experiences*	1,0
8: Active Learning	2,0
9: Enhancement of Faculty CDIO Skills*	1,0
10: Enhancement of Faculty Teaching Skills	2,0
11: CDIO Skills Assessment*	0,0
12: CDIO Program Evaluation	0,0
	15,0

Creating the Model

The CDIO self-evaluation scale (0-4) with its' explanations describes the progress in implementing CDIO in a program very similarly than the innovation process and the level of adoption in a university as does. The basic idea in our model is that the scales of the CDIO self-evaluation model and the phases of the innovation process in an organization have

something in common (Table 3).

Table 3. Connecting the theories.

Program evaluation scale		Phases of the innovation process in organizations	
Scale	Description	Phase	Description
0	No initial program-level plan or pilot implementation	Agenda-Setting	General organizational problems that may create a perceived need for innovation
1	Initial program-level plan and pilot implementation at the course or program level	Matching	Fitting a problem from the organization's agenda with an innovation
2	Well-developed program-level plan and prototype implementation at course and program levels	Redefining/ Restructuring	The innovation is modified and re-invented to fit the organization, and organizational structures are altered
3	Complete and adopted program-level plan and implementation of the plan at course and program levels underway	Clarifying	The relationship between the organization and the innovation is defined more clearly
4	Complete and adopted program-level plan and comprehensive implementation at course and program levels, with continuous improvement processes in place	Routinizing	The innovation becomes an ongoing element in the organization's activities and loses its identity

When we connect the CDIO self-evaluation model ratings with the phases of the innovation process in an organization, we can analyze single standards and give more descriptive definition about the situation the university has. The descriptions of the innovation phases provide additional and more descriptive information on the implementation process. If a standard is rated one for example, we can say the organization is in the matching phase in relation to this standard and the standard is fitted to organization's agenda. Furthermore, the sum of the ratings of the standards represents the overall situation of the university in the CDIO innovation adoption process. As we remember, 48 points was the maximum in self-evaluation. When we divide the whole scale equally to five levels, we have a proposal for interpreting the overall situation. Organizations having up to ten points are still in the agenda-setting phase where the general organizational problem is defined creating the need for an innovation. The organization has recognized a performance gap i.e. discrepancy between their expectations and its' actual performance. Organizations having 11 to 20 points are in the matching phase where the organizational problem is fitted with the innovation and this match is planned and designed. In redefining/restructuring the organization and the innovation are re-invented to accommondate the needs and structures more closely. Organizations having over 30 points have CDIO initiative in widespread use. When the innovation looses its separate identity in the organization and is part of normal activities the organization is in the routinizing phase.

Table 4. Rating categories.

Low	High	Phase
0	10	Agenda-Setting
11	20	Matching
21	30	Redefinining
31	40	Clarifying
41	48	Routinizing

The organizational results provide guidelines for continuous development. The analysis can be turned into action points where each standard is presented in the innovation process phases. A program might have evaluated their success in implementing the standards and the broadened model shows current and next activities relating to each standard (see example in Table 5). This example shows that the program has been active with the standard four and their next step with the standard four should be routinizing it i.e. making it an ongoing normal element in the program. Similarly they haven't paid much attention to Syllabus Outcomes and they should enter into redefining phase i.e. redefine and restructure their syllabus outcomes.

Table 5. Example of an evaluation.

Standard	Rating	Now	Next
Standard 1: CDIO As Context*	2	Redefining	Clarifying
Standard 2: Cdio Syllabus Outcomes*	1	Matching	Redefining
Standard 3: Integrated Curriculum*	2	Redefining	Clarifying
Standard 4: Introduction To Engineering	3	Clarifying	Routinizing

Furthermore, the innovation attributes offer possible tools to evaluate the rate of adoption of the CDIO standards. A program can analyse the standards using the attributes and get addition support for decision making in the development of education. A possibility is to use a five-level scale: Very Low – Low – Moderate – High – Very High that can be converted to numbers 0 to 4 corresponding to the previous scale. However, Complexity attribute has negative influence in the adoption of innovations and in this case the scale was turned upside down in the conversion to numbers. Finally, all numbers are added up to calculate an orientation value towards the adoption of CDIO Standards. This orientation value can be expressed in percentage terms. The maximum orientation value is 16 (100 percent) and the lowest orientation value is zero (0 percent). The orientation value is not a timeless indicator, rather it describes the situation at certain point of time. The higher the value, the better prerequisites the organization has to adapt to the current standard. Thus the evaluation tries to point out areas in which improvements are needed to enhance innovativeness.

Testing the Model

The school of Telecommunication and e-Business has used the CDIO self-evaluation model two times. The first time was in December 2007 and the evaluation was made by the management team of the school. The evaluation was made for each of our programs. The second time was in the school's development day in January 2008. This time the evaluation was made by the whole personnel at small 4 to 6 people groups. The mixture of the group

determined the program that was evaluated in each group. Different groups worked independently of each other and some groups wrote rationale to their assessment. Both results are introduced in the following tables (Table 6 and Table 7).

Table 6. Evaluation results - part 1.

	Information Technology				Electronics		
	Mgmt	G1	G2	G3	Mgmt	G4	G5
St. 1	1	2	1	1,65	1	2	2
St. 2	2	2	2	0,7	2	2	2
St. 3	2	3	2	2	2	0,3	2
St. 4	2	1,5	1	0,6	3	2	3
St. 5	3	2	0	3	3	3	3
St. 6	3	3	4	3,3	3	3	3
St. 7	3	2	2	3,15	3	3	2
St. 8	2	2	3	3,5	2	2	2
St. 9	3	2,25	1	3,2	3	2	3
St. 10	2	2	3	3	2	3	3
St. 11	1	2	1	1,4	1	3	1
St. 12	1	1,5	0	1	1	0	0
	25	25,25	20	26,5	26	25,3	26

Table 7. Evaluation results - part 2.

	Information Technology (in english)		Business		Information and library services		Business IT
	Mgmt	G7	Mgmt	G6	Mgmt	G8	Mgmt
St. 1	1	4	1	4	1	1	1
St. 2	2	2,5	2	2	2	2	2
St. 3	2	3	2	3	2	2	2
St. 4	1	1	4	4	0	3	1
St. 5	3	4	3	3,5	2	3	2
St. 6	3	3	3	3,5	3	3	3
St. 7	3	2,5	3	2,5	3	2	3
St. 8	2	4	2	0,75	2	2,75	2
St. 9	3	1	3	1,75	3	3	2
St. 10	2	1	2	3	2	3	2
St. 11	1	2,5	1	3	1	2	1
St. 12	1	0	1	2	1	2	1
	24	28,5	27	33	22	28,75	22

Next step in testing the model is defining the current phase in each standard. This could be done with each program separately, but we will use combined ratings as presented in Table 8. Ratings in Mgmt-column are average ratings of our management group ratings for each program. Ratings in Personnel-column are average ratings of the groups 1 - 8. The combined value is average of the Mgmt and Personnel ratings. In overall our school has an evaluation rating of 25.1, which means that our school is in Redefining phase of the innovation process.

Phases of the individual standard are shown in the Table 8. The evaluation now shows that there is one standard in the agenda-setting phase, four standards in the matching phase, seven standards in the redefining phase and one in the clarifying phase. If the implementation is wanted to progress broadly, the focus should now be put on the standards that are in the lower phases of the innovation process. It is also possible to analyze the standards in more detailed way using the innovation attributes, but in this paper we will not continue the evaluation using the innovation attributes.

Table 8. Evaluation of the School.

Standard	Mgmt	Personnel	Combined	Now	Next
1: CDIO as Context*	1,0	2,2	1,6	Matching	Redefinining
2: CDIO Syllabus Outcomes*	2,0	2,0	2,0	Matching	Redefinining
3: Integrated Curriculum*	2,0	2,0	2,0	Redefinining	Clarifying
4: Introduction to Engineering	1,7	1,9	1,8	Matching	Redefinining
5: Design-Build Experiences*	2,6	2,5	2,5	Redefinining	Clarifying
6: CDIO Workspaces	3,0	3,2	3,1	Clarifying	Routinizing
7: Integrated Learning Experiences*	3,0	2,4	2,7	Redefinining	Clarifying
8: Active Learning	2,0	2,5	2,3	Redefinining	Clarifying
9: Enhancement of Faculty CDIO Skills*	2,7	2,2	2,4	Redefinining	Clarifying
10: Enhancement of Faculty Teaching Skills	2,0	2,6	2,3	Redefinining	Clarifying
11: CDIO Skills Assessment*	1,0	2,0	1,5	Matching	Redefining
12: CDIO Program Evaluation	1,0	0,8	0,9	Agenda-Setting	Matching
	24,0	26,3	25,1	Redefining	Clarifying

Finally, the progress of the program development and the results of working with the standards can be shown in a longitudinal presentation (Figure 3). Most of the data on this graph come from the CDIO-website, but our School evaluations have been combined there.

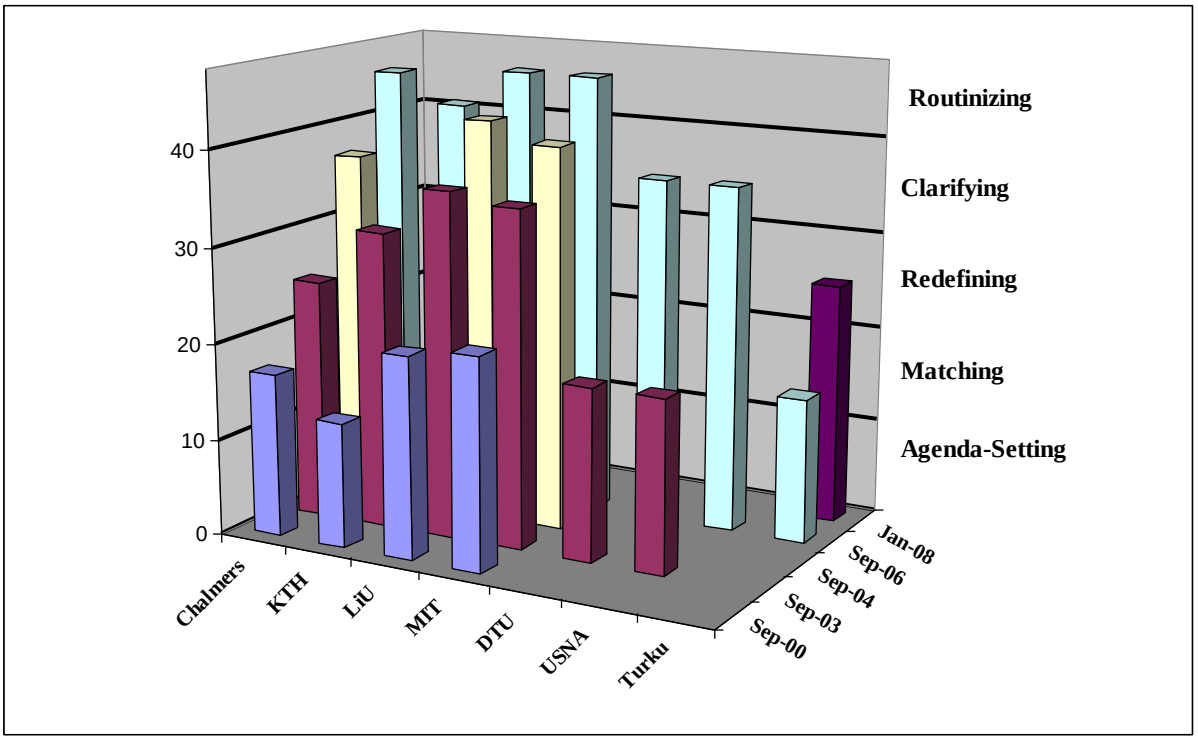

Figure 3. Progress of the innovation process in different HEIs.

Discussion

The aim of this study was to propose an extension to the CDIO self-evaluation model. The extension that was proposed based on the innovation process in organizations -model in the diffusion of innovations theory. This study showed that the five ratings in the CDIO self-evaluation model and the five phases in the innovation process in organizations -model are very similar to each other. We planned that combining the innovation process to the analysis of the implementation process would support the interpretation of the evaluation results. The testing of the model hopefully showed that there is additional information available through the extension.

The presented case where evaluations made by the management team and the personnel were combined showed that the standards are well defined and the evaluation is supported by the well-written standard descriptions. The independent evaluation of different groups produced quite similar results in most programs. A good example is the evaluations of the Degree Program in Electronics (see Table 6): three independent evaluations that were all between 25.3 and 26.

The CDIO self-evaluation model functions surprisingly well. The personnel is typically not very excited to speak about quality assurance or quality in general. The CDIO self-evaluation model starts from the concrete topics and deals with the quality matters in a very understandable way that keeps the personnel excited.

For our School, the new model has been useful. The model with extension has showed the focus areas that are least developed at the moment. Based on these analyses we have started our development actions answering the identified challenges. First of all, we defined CDIO as our main ideology or framework for arranging education. Another concrete step was the

definition of Introduction to -courses in all our degree programs. These courses have their first implementation next autumn. Furthermore, we have started an education package around active learning. Finally, a small group of teachers have designed a reform in our assessment.

When HEI's want to have evidence of their continuous improvements they need to systematically analyze their progress like Figure 3 showed. It is especially important that the evidence is collected and saved in a reasonable place.

Conclusions

This study has proved that the CDIO initiative is like an umbrella that covers the whole playground of higher education. It is an initiative that management and personnel can easily commit. The self-evaluation model provides necessary tools for target development actions and to enhance continuous improvements in higher education.

The proposed extension is easy to use and it gives additional information about the progress. Still, in the name of quality assurance, even more important is that the documentation - the evidence - is in order and available.

Finally, even though CDIO initiative is not a quality assurance tool, it certainly is a package that has a positive influence on the quality of higher education. Hopefully the proposed extension can support this continuous improvement process.

References

[1] Council of European Union. *The concrete future objectives of education and training systems - Report from the Education Council to the European Council*. 5680/01 EDUC 18 2001 [cited 2008 16.5.]; Available from: http://ec.europa.eu/education/policies/2010/doc/rep_fut_obj_en.pdf.

[2] European Union. *Facing the challenge - The Lisbon strategy for growth and employment*. 2004 [cited; 54]. Available from: http://ec.europa.eu/growthandjobs/pdf/kok_report_en.pdf.

[3] Ministry of Education, *Valtioneuvoston koulutuspoliittinen selonteko eduskunnalle (in Finnish)*, in *Publications of Ministry of Education 2006:24*. 2006, Ministry of Education. p. 92.

[4] ARENE, *The Bologna Process and Finnish Universities of Applied Sciences*. 2007, Helsinki: Edita Prima Oy.

[5] Department for Education and Skills. *The future of higher education*. 2003 [cited 15.3.2006]; Available from: http://www.dfes.gov.uk/hegateway/uploads/White%20Pape.pdf.

[6] SITRA, *Making Finland a leading country in innovation : Final report of the competitive innovation environment development programme*. 2005. p. 35.

[7] Ministry of Education, *Korkeakoulujen rakenteellisen kehittämisen periaatteet; Keskustelumuistio 8.3.2006 (in Finnish)*, in *Opetusministeriön monisteita 2006:2*. 2006.

[8] Ministry of Education Finland, *Tekniikan alan korkeakoulutuksen ja tutkimuksen kehittäminen.* Opetusministeriön työryhmämuistioita ja selvityksiä, 2005. **2005:19**: p. 91.

[9] Finnish Higher Education Evaluation Council, *Korkeakoulujen*

laadunvarmistusjärjestelmien auditointi - Auditointikäsikirja vuosille 2008-2011 (in Finnish). 2007(7).
[10] Davies, J., et al., *THEMATIC REVIEW OF TERTIARY EDUCATION - Finland country note*. 2006, OECD.
[11] CDIO. *The CDIO Initiative*. 2007 [cited 5.1.2007]; Available from: www.cdio.org.
[12] Rogers, E.M., *Diffusion of innovations*. 5th ed. 2003, New York: The Free Press.
[13] Gray, P.J., *Program evaluation*, in *Rethinking Engineering Education - The CDIO Approach*, E. Crawley, et al., Editors. 2007, Springer. p. 195 - 215.
[14] Zaltman, G., R. Duncan, and J. Holbek, *Innovations and organizations*. 1973, New York: John Wiley & Sons.

Correcponding author
Dr. Juha Kontio
Director of Education
The School of Telecommunication and e-Business
Turku University of Applied Sciences
Joukahaisenkatu 3 C
20520 Turku

Tel: +358 50 385 4122
Juha.Kontio@turkuamk.fi