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Quality Management in Institutions of Higher Education as a Feedback Control Problem

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***Abstract* — Assurance and improvement of quality in institutions of higher education has been moved into the focus of the Bologna process since five years. While political and educational aspects of quality problems in institutions of higher education have been analyzed thoroughly, the mechanisms and particularities of feedback control in quality management of these institutions need to be analysed in more detail, which is done in this article.**

I. Introduction

As a result of the 2003 Bologna Follow-up Conference [1], the European Ministers in charge of higher education committed themselves to supporting further development of quality assurance at institutional, national and European level. They called upon ENQA, the European Association of Quality Assurance in Higher Education, amongst others, to set standards, procedures, and guidelines for quality assurance in higher education. ENQA published these 2005. Valuable hints are given in this paper concerning headline goals. Details of implementation are left to the responsible institutions and organisations on purpose, since circumstances are different at different places.

Therefore, this article aims at helping in preparing implementation and analysis of concrete quality management systems.

If a quality management system is to be set up, then some basic principles must be understood beforehand. On a first view, the impression might evolve that quality management does only need common sense, since it follows simple principles. However, this is an error.

Quality assurance and quality enhancement systems are typical examples of feedback control systems. From them it is known that well meant measures might remain without success, or even worse, that they might cause a converse effect. It is all the more surprising that only few papers on quality control in higher education refer to the results of control theory and its applications, in order to avoid typical mistakes.

Therefore, a short overview over feedback control is given in the following without going into too theoretical details. Then, consequences will be derived with respect to institutional and programme quality management.

II. Basics of Feedback Control

Feedback control is best understood when demonstrated with a simple example, which *on purpose* is *not* taken from quality control, in order to identify the most important points more easily. In that example, think of a car-driver who is to steer a car round a curve. The lane is where the car is supposed to move. It is the reference location, or the "desired outcome". It might well be that the car is not (yet) on the correct lane. Its proper position is the actual location, or the "actual outcome". The driver sees the deviation between desired and actual outcome. Depending on the directness of the steering wheel, the driver reacts more or less forceful in order not to overreact when turning the wheel. This action will change the driving direction. Provided that this action was well adapted to the needs, the car will move close to the desired location. If not, then further actions will (hopefully) move the car into the right direction. Since any reaction to an action is brought back to the comparator device, the complete process is called "feedback control".

This process might be formally described by the diagram in Fig. 1.

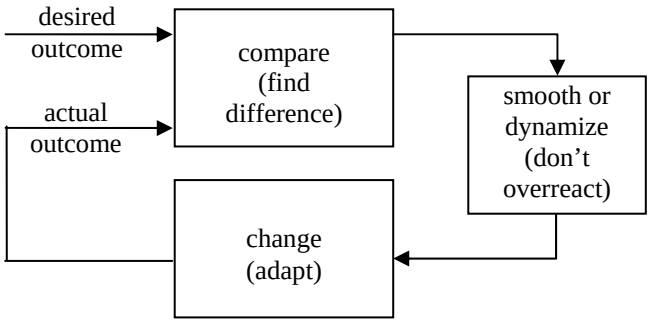

Fig. 1 Illustration for feedback control

The given model demonstrates some essential points of feedback control.

1. There must be a clear, verifiable and detailed *definition of the desired outcome*.

   Without that, sensible and quantifiable comparison to the actual outcome is not possible!

   In the given example, for instance, it does not suffice, to require "the car to be moved round a corner", since this formulation leaves open whether to turn left or right, to follow what curve, under which boundary conditions, etc. It goes without saying that without this information, controlled motion is impossible.

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2. The *actual outcome must be measurable*.

   If the actual outcome is not measurable, then no comparison might be performed between desired and actual outcome.

   In the given example, for instance, it does not suffice to state that the car is "on the lane", it rather must be exactly said where on the lane it is, and which velocity it actually has.

3. There must be *means to compare and to assess*,

   more exactly, there must be means to compare actual and desired outcomes that yield information about at least the direction of the deviation between actual and desired outcomes, and preferably also about the magnitude of the deviation. In more complex cases, a more sophisticated function of desired and actual outcomes, a so-called weighting function, which assesses the comparison, is given as a result of comparison.

   If comparison is not possible, then there is no information available on what and how to change.

   In the given example, for instance, comparison is done by the eye/brain system of the driver, and this might be a weak point of this control loop, since sometimes the eye/brain system does not give information that is accurate enough.

   The importance of comparison might even be made clearer, if the experiment is changed a bit. Think that the driver is forced to drive the car blindfolded, and that a front passenger is to give the necessary visual information by calling. It does not suffice that the co-driver tells to move the steering wheel, it must also be said to which direction, and how strongly to turn the wheel.

4. There must be *means to change*,

   more exactly, there must be at least one subsystem where a change could be enforced to influence the actual outcome significantly into the one or the other direction. Without that subsystem, there would not be any possibility to adapt.

   In the given example, the necessity of using a steering means is self-evident.

5. There must be *means to dynamise*,

   more exactly, there must be means to smooth or to amplify reactions to measured differences between desired and actual outcome in order to avoid too strong or too weak reactions.

   In the given example (with the blindfold driver), the co-driver must indicate whether rotation of the steering wheel is too strong or too weak, in order to avoid that the car leaves the lane and possibly hits a pedestrian.

III. A FIRST APPLICATION TO QUALITY MANAGEMENT IN HIGHER EDUCATION

The above given model is still quite simplifying, but it is already fit to discover severe shortcomings of a suboptimally or a faultily designed feedback control system. As an example, consider quality assurance in a bachelor course program that is to be set up or that is to be assessed. Going through the individual points of the last section, the following is found:

1. (*definition of the desired outcome*)

   In quality assurance of a study course program, it does not suffice to require quite general knowledge, skills, and competences, as for example given in the European Qualifications Framework (EQF). These would require that the student should acquire "advanced knowledge of a field of work or study, involving a critical understanding of theories and principles", "advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study", and "the competence to manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts take responsibility for managing professional development of individuals and groups."

   It is obvious from the discussion on the last section that for a good set-up, concrete, measurable criteria are missing. What is "advanced knowledge"? What is "critical understanding"? What is "managing a complex project" in concrete terms?

   To make that quite clear: This is not a critique on the EQF! It is simply a demonstration that the formulations of the EQF do not suffice at all in order to define the "required outcome"! Any institution of higher education setting up a bachelor course program must put further effort into the clear formulation of the desired outcomes.

2. (The *actual outcome must be measurable*)

   Knowledge, skills, and competences of a student who is to be awarded a degree must be measurable. For that purpose, exams must be passed. But do these exams really test skills and competences apart from knowledge? Sometimes, this might be doubted! There are still enough institutions, where learning objectives are not yet formulated, let alone tested.

3. (There must be *means to compare and to assess*)

   Though the requirement for comparator means appears to be simple, it includes difficulties in detail, particularly concerning assessment. If 80% of a cohort of students pass with good or excellent results, but 10% fail, is that compliance with requirements? Or is it better, if 95% pass with only satisfying results, but only 5% fail? In concrete cases, this must be clearly decided *beforehand*, since it will also influence the

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way how the system is to react on deviations between actual and desired outcomes.

4. (There must be *means to change*)

   This is the point that is easiest to understand. It is quite clear that without such a tool, it is not possible to correct undesirable developments. Nevertheless, this might also be the point most difficult to set up. If for example in a bachelor course program one particular lab course always finishes with only 40% of passed exams, then there is certainly something to change. (To find the causes, it might be very advantageous to include external assessors). What, if the deeper reason is inadequate special equipment? What, if the institution is not in a situation or is not willing to spend the money to pay for this equipment?

   In more complex systems, there might be other solutions, namely to change something different. Is it really necessary to have this particular lab course? Couldn't there be another course that gives students the opportunity to achieve similar competences?

   In other words, is the only point to change financial means, or is there another parameter to change? Proper design of a quality management system must take these possibilities into consideration.

5. (There must be *means to dynamise*)

   Not all findings about deviation between desired and actual outcomes need immediate and forceful reaction.

   It might happen, for instance, that a midterm-exam for a particular educational module results in very bad marks, maybe, because of some individual events. Normally, it would be an overreaction to fire the lecturer, or to expel these students from the institution. Rather, it would be a better idea to find out more about the true reasons, to let calm down persons concerned, and to react with weaker consequences.

   On the other hand, if for example damage of a building would put at risk life or health of students and staff, then immediate and rigorous actions would be needed.

   It is thus necessary to react more or less forcefully. The design of a quality management system must leave these possibilities to adequately react.

The above described conclusions may sound self-evident. However, they are not.

When the author was asked recently to assess a bachelor-course program of engineering (not in his own country), his first question was: Have you defined a list of measurable learning-outcomes that every student must achieve? The answer was that this be not necessary, since every lecturer would know what is necessary. To the question what would happen, if industry would tell that the profile of education of this university would not fit to needs, the answer was that this be unfortunate, but there would not be any possibility to change, since lecturers could not be convinced to change. It is obvious that such a system cannot fix its problem of quality without a rigorous re-design.

While the above example is an extreme case, even in very advanced European systems of higher education some confusion might be found about interrelations and mechanisms of action in quality assurance.

One example is the ongoing debate about "External expert panel's evaluation vs. research based evaluation of higher education". If it is agreed upon that research based criteria are used to uniquely and testable formulate the desired outcomes, and if it is made sure that external expert panel's evaluation is part of the comparator means in the feedback loop (which needs clearly defined test procedures), then there is not an "either /or" of both, but an "as well as".

IV. More complex relations

As it was already mentioned, the given model of quality control as a feedback control loop is still too simplifying. This might be seen by asking the question why quality management systems from business companies could not be directly applied in higher education.

First of all, graduates are not merchandise. Universities do not automatically get more money for alumni the better these alumni are educated! Alumni are not returned to university, if they do not work adequately! Therefore, weighting functions assessing the deviation between desired outcomes and actual outcomes do not give a direct measure. Furthermore, in contrast to most commercial products, it is not always possible to define exactly on a commonly agreed basis what a desired outcome of higher education would be. (Nevertheless, a definition must be given by the institution).

Second, any feedback on the quality of students of an institution comes only back after years, since it takes a while to find out about the average quality of graduates from one particular course program. Therefore, the overall feedback-loop of quality management at universities includes enormous delay times, even with more than five to ten years delay. Mathematical theory of feedback loops with delay reveals that these tend to oscillate or to completely break down. Indeed, if a deviation between desired and actual outcome is discovered in such a system, then influencing the system might drive it into direction of a better state. However, if feedback is delayed for a too long time, then the optimum point will not only be reached, but it will be left by continuing its change and the amount of deviations will increase again. Therefore, only very careful and smooth reactions in such a system lead to success. *By no means, violent changes must be applied* in a system with large delay times.

Third, the dynamic behaviour of systems of higher education follows completely different rules as compared to producing business companies.

Fourth, systems of higher education are not consisting of one feedback loop for quality alone. Rather they are very complex nested systems of feedback loops. Optimizing one parameter for quality might easily impair the quality of another parameter.

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What could be done to overcome these problems? The first problem could be tackled by a combination of educational research and a market analysis concerning the needs of the labour market. In particular the latter is not an easy task to do, since sometimes wrong questions are asked. An example might be used for illustration. Many American and European universities use to query their alumni to find out the actual needs. One of the popular questions is "How many percent of what you have learnt during your studies could you use in your job?" The answer is mostly quite disappointing since factual knowledge might grow old quite quickly. A much more sensible question would have been for the methodology that was learnt rather than for the factual knowledge. However, proper formulation of these questions and response to them would need some knowledge about learning theory, which most alumni did not get to know during their studies (and which many lecturers have never heard of).

The problem of long delay times can be tackled by at least two different methods. First of all, do not change too quickly. As a rule of thumb, estimate an amount of time for a complete change of state that is double the amount of the delay time, since then in case of failure, the system could be prevented from complete break-down. The second method is to attempt to find look-ahead measures for success or failure.

For the problem of nested loops, a careful analysis is necessary concerning the interrelations between the parameters to be optimized. A proven means of controlling such systems is to find or create (nearly) independent parameters to be controlled, where a change of one parameter does (nearly) not influence the other parameters[1]. In systems with parameters that are controlled with different delay times, it is common to separate for control loops whose velocity of reaction differ by orders of magnitude, if possible.

V. Discussion

The above analysis has shown that systems of quality management at institutions of higher education might be interpreted as nested feedback loops, each following rules, some of which are simple and easy to understand, but nevertheless essential to follow, and some of which are quite complex.

In particular those rules that are simple to check and to understand have been discussed in detail. Their application might reveal some shortcomings in existing systems of quality management. A prominent example is illustrated in the following.

If the Bologna-process is interpreted as a large Europe-wide system for the improvement of quality in higher education, then it might be seen easily that this quality management system fails to meet at least one of the simple rules given: The desired outcome has not been defined properly. One of the requirements of the Bologna process was the adoption of a system of easily readable and comparable degrees. These requirements have never been stated precisely in a sense that it was clearly and measurably defined what is meant by "easily readable" and by "comparable" with respect to university degrees. As a consequence, legislators defined what they as jurists understood by these terms in their countries. The result is that now in Europe "easily readable" and "comparable" means that the *naming* of the degrees has been standardised, and not much more. This is not a failure of the feedback system. It does exactly what it was designed for. Rather it is a failure of the design.

This opens the debate of what is a "desirable outcome", which is beyond the scope of this article, though. How important the answer to this question is might be demonstrated by an event that happened in another European country. There, education of nurses has been reformed to fit into the Bologna process. At the same time, these programs were required to be based more strongly on science. For that purpose, it was desired that a certain percentage of educators would hold a Ph.D. degree. As a consequence 30 out of 31 programs did not get accreditation on the first run, because they could not restructure their staff fast enough. It might be debated whether in this case the formulation of desired results led to desirable results.

There is another question that must be asked in that context, since the formulation of desired results is significantly influenced by experts. This question is: What must be the skills and competences of experts in quality assessment of institutions of higher education and their programmes? Is a good assessor of programs for engineering courses also a good assessor of courses in philosophy? Is a good assessor for quality in educational programmes also a good assessor for quality in research? Is a good assessor for quality in either of these also a good assessor for institutional quality? Is a president of a university a good assessor for institutional quality?

It might be suspected that all the skills and competencies for managing quality in education, research in, and administration of a university is united only seldom in one single person. And it might also be suspected that in most European countries, institutional quality management in higher education is still in a state of development.

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[1] Engineers recognise this problem as one of orthogonalisation.