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# Comparative Quantitative Study on Learning Outcomes of Major Study Groups of an Information and Communication Technology Bachelor Educational Program

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***Abstract*—**Higher Education system reforms, especially Finnish system of Universities of Applied Sciences in 2014 are discussed. The new steering model is based on major legislative changes, output-oriented funding and open information. The governmental steering reform, especially the financial model and the resulting institutional level responses, such as a curriculum reforms are discussed, focusing especially in engineering programs. The paper is motivated by management need to establish objective steering-related performance indicators and to apply them consistently across all educational programs. The close relationship to governmental steering and funding model imply that internally derived indicators can be directly applied. Metropolia University of Applied Sciences (MUAS) as a case institution is briefly introduced, focusing on engineering education in Information and Communications Technology (ICT), and its related programs. The reform forced consolidation of previously separate smaller programs into fewer units of student application. New curriculum ICT students have a common first year before they apply for a Major. A framework of parallel and longitudinal comparisons is introduced and used across Majors in two campuses. The new externally introduced performance criteria are applied internally on ICT Majors using data ex-ante and ex-post of program merger. A comparative performance of the Majors after completion of joint first year is established, focusing on previously omitted Majors for completeness of analysis. Some new research questions resulting from transfer of Majors between campuses and quota setting are discussed. Practical orientation identifies best practices to share or targets needing most attention for improvement. This level of analysis is directly applicable at student group and teaching team level, where corrective actions are possible, when identified. The analysis is quantitative and the nature of the corrective actions are not discussed. Causal relationships and factor analysis are omitted, because campuses, their staff and various pedagogical implementation details contain still too many undetermined factors for our limited data. Such qualitative analysis is left for further research. Further study must, however, be guided by the relevance of the observations.

***Keywords*—**Engineering education, integrated curriculum, learning outcomes, performance measurement.

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## I. Introduction

THE Finnish system of Applied Science Universities experienced a major administrative reform [1] in 2014. All institutions obtained an independent legal status. In reforms of 2014, 2015 and 2016 also their funding was significantly changed to a strongly output-oriented and mutually competitive model. This chapter summarizes the rationale in educational system and institutional levels, followed by a brief review of our related work and the research objective.

### *A. Higher Education System Reforms*

Tertiary education structures and costs have been under public discussion on all of the OECD-countries since recession of 1990’s and the rise of the concepts of New Public Management (NPM). Yet again, since the new financial crisis of 2008, the discussion on public spending in Higher Education has resulted radical reforms. Finnish universities were detached from direct government budgeting in 2010 and they received independent legal status. Universities of Applied Science, an equal size sector of 24 institutions, received this possibility already in 2008. The last remaining ones were finally forced to independent new status in 2014.

Independent legal status increases autonomy and accountability. Funding models are the second key instrument on governmental steering of the Higher Education Institutions. The funding model has been revised gradually towards an output-oriented approach. The most radical revisions were in 2014 to 2016 [2]. Then 85% of the funding was decided to be based on earned ECTS (European Credit Transfer System) credits and calculated in a trigger-based way: Student who achieves 55 of nominal 60 ECTS will produce one unit of funding and any less will produce zero funding [2]. Clearly, such steering will have strong impact at institutional and program levels.

MUAS is the largest University of Applied Sciences in Finland. MUAS has around 16.700 students and 1.000 staff. About half of the students are in engineering. MUAS ICT is a four year Bachelor-level Degree Program of 240 ECTS (European Credit Transfer System) credits with around 1000 students at two campuses: Helsinki campus and Espoo campus [3] as indicated in Fig 1.

The reform also forced consolidation of previously separate smaller programs into fewer units of study for students to apply [1]. Health Technology (Entry groups H10-H13) was merged into the ICT in 2014 and appeared back as one of its Majors (H14) in 2015. Similar merger was introduced to another previously independent program: Media Engineering (M10-M13), appearing back as Media Technology Major (M14) of ICT in a similar way. The overall structure of the ICT curriculum is presented in more detail in [4] and [5]. Here it is sufficient to note that the first year of studies are same in both campuses and the ICT Majors are selected at the end of the first year.

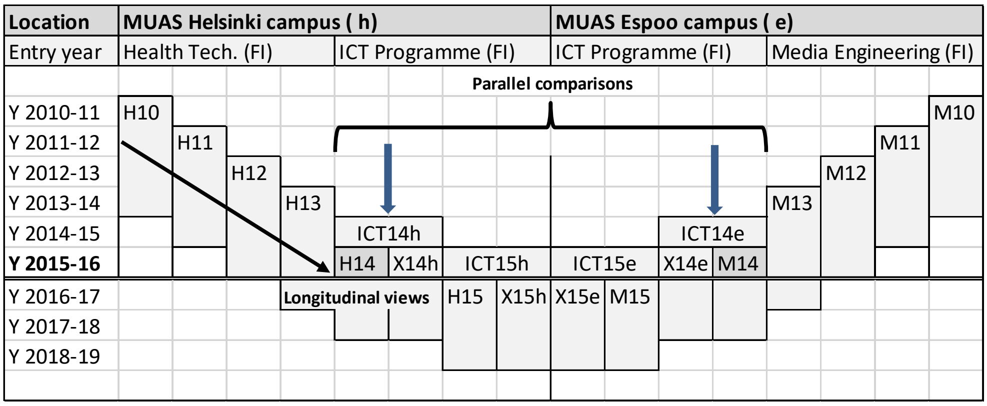


Fig. 1 Framework of performance analysis between campuses and merged programs

### B. Our Related Work

The background and rationale of the reforms and MUAS as an institution can be found in [4]. Initially the performance indicators were first used reflectively [5] with some corrections in sampling in [6].

Common to all MUAS engineering programs is a shift towards larger teaching and learning units of work, as shown in ICT [4], Electronics [7], and in Automation Technology [8]. The shift is consistent with positive learning outcomes of the first year 15 ECTS intensive modules.

Case studies on student learning experience [9] in Health Technology and the improving quantitative indicators suggest a correct direction. Larger modules of learning in network technologies are suggested also by our previous work [10] on competence-based curricula [11]-[13]. Health Technology as a multidisciplinary program is, especially in Bachelor level, highly competence-based due to the partly unstructured domain of practical problems.

Metropolia is not formally committed in an institutional level to widely accepted engineering education concepts, such as the CDIO-initiative [14], [15]. Due to the multidisciplinary nature of four distinct fields of study, this was considered too restrictive. The curricula and the positive achievements in engineering education, such as first year projects and capstone project (called Innovation project) reflect the principles. Health Technology has capstones within each thematic semester [9]. A new case study [16] analyzes the second thematic semester.

### C. Research Questions

Continuing the earlier work we further analyze the MUAS Espoo campus performance indicators of Media Technology (M) as a parallel case to Health Technology (H) to establish comparative position. We restrict to two first years of the new curriculum, without baseline history.

Game programming Major was discontinued at Helsinki campus (P14h) and merged with its parallel group at Espoo campus (P14e), denoted as P14. The baseline criteria are applied to these two groups before they merged to form their baseline for later analysis. Staff also moved and entry quota limitation was set for next Major entry P15. The new factors to be analyzed are initially considered.

## II. Materials and Methods

The analysis is based on the database of student records between academic years 2008-2016. The data cover the previous curricula since the Metropolia's initial merger 2008 and the current curricula since 2014. Summary reports of a student entry group are available from the data, but they are re-processed to analyze the effect on trigger-based criteria yearly and student level. The results are summarized and presented as performance indicator data sets. Percentages are used to enable comparison of different sizes of groups. As discussed in [5], care is necessary in using and interpreting the denominator N.

Due to discontinuity of records system during fall 2016 and the fact that the criteria need full academic year to trigger, is prudent not to perform intermediate analysis during the year.

The remaining Majors in Helsinki Campus are Software Engineering and Health Technology. The potential of closer relationship between these Majors is discussed and identified.

## III. Results

### A. Program Baseline Performance Indicators

Program baseline performance indicators of the new funding model are retrospectively calculated against the pre-reform student data. This establishes the baselines for comparison between the programs before the reform. The criteria are applied to Majors of the post-reform curricula.

The performance indicators of the sampled data are aggregated from student and year levels up to entry group and year level, as shown in Table I. The 4-year program is shown in first column. Each student has 5 year time to complete it (Overtime 1) and the UAS can allow one more year (Overtime 2), if appropriate. In addition, a student has an individual right to register as being absent for 4 full semesters, i.e. two years. Therefore, the use of entry years to describe the actual pedagogical performance is inaccurate at student level. The main rationale of using entry group data anyway is that it is descriptive of performance at the system level and it records each student in one category only. This is also the reason of sampling many years of H- and X- data and aggregating them before comparison, to eliminate this variable and stabilize the indicators.

TABLE I
PROGRAM PERFORMANCE BY NEW FUNDING CRITERIA

| | H10 (Entry group) | | | | |
|---|---|---|---|---|---|
| Study years | N | ECTS | Avg | n(>54) | n/N(%) |
| 1. Year | 40 | 1673 | 41,8 | 17 | 42,5 |
| 2. Year | 40 | 992 | 24,8 | 8 | 20,0 |
| 3. Year | 40 | 1023 | 25,6 | 10 | 25,0 |
| 4. Year | 40 | 635 | 15,9 | 4 | 10,0 |
| Overtime 1 | 40 | 90 | 2,3 | 0 | 0,0 |
| Overtime 2 | 40 | 18 | 0,5 | 0 | 0,0 |

Column N shows the student entry group size, ECTS is the total number of European Credit Transfer System credits earned by this cohort of students by their study year in total. Avg indicates the average level ECTS/N of learning outcome. If the target is 55.0 the result is very much insufficient. The column n(>54) shows number of students within the cohort who achieved 55 ECTS or more. The results seem low. For comparative analysis, the last column n/N(%) indicated the ratio of acceptable performers against the whole cohort. Aggregated Health Technology (H10-H13) and ICT Helsinki (X10-X13h) baselines pre-merger are shown in Table II.

TABLE II
PROGRAM BASELINE PERFORMANCE COMPARISON

| | H10-H13 Totals | | | X10-X13h Totals | | |
|---|---|---|---|---|---|---|
| Study years | N | Avg | n/N(%) | N | Avg | n/N(%) |
| 1. Year | 147 | 55,5 | 58,5 | 448 | 37,4 | 31,7 |
| 2. Year | 147 | 38,3 | 37,4 | 448 | 31,1 | 33,0 |
| 3. Year | 147 | 34,5 | 34,7 | 448 | 26,7 | 27,2 |
| 4. Year | 105 | 22,4 | 14,3 | 341 | 17,6 | 8,8 |
| Overtime 1 | 73 | 3,5 | 0,0 | 229 | 7,9 | 2,6 |
| Overtime 2 | 40 | 0,5 | 0,0 | 108 | 3,6 | 0,0 |

The n/N(%) indicator appears to be quite descriptive in showing significant difference, specifically in the first year. The significantly higher performance of H-groups was one of the concerns prior to the merger of H to X: the competitive edge of a small program.

### *B. Longitudinal Performance Evaluation*

A longitudinal follow-up of the student cohorts of all ICT majors in 2015 are traced back to their original entry cohort of 2014. This allows for analysis over the two years of performance. The same criteria are applied on their first year in retrospect. The pre- and post-reform performances are shown in Table III for Health Technology as aggregated (H10-H13) by study years and comparatively H14 over two first years of data available. The analysis shows the longitudinal performance and trend compared by curricula.

TABLE III
HEALTH TECHNOLOGY BASELINE AND LONGITUDINAL VIEW

| | H10-H13 Totals | | | H14 Totals | | |
|---|---|---|---|---|---|---|
| Study years | N | Avg | n/N(%) | N Adm. | Avg | n/N(%) |
| 1. Year | 147 | 55,5 | 58,5 | 39 | 53,4 | 79,5 |
| 2. Year | 147 | 38,3 | 37,4 | 39 | 56,9 | 82,1 |
| 3. Year | 147 | 34,5 | 34,7 | | | |
| 4. Year | 105 | 22,4 | 14,3 | | | |
| Overtime 1 | 73 | 3,5 | 0,0 | | | |
| Overtime 2 | 40 | 0,5 | 0,0 | | | |

The first observation is that the aggregated (H10-H13) indicator n/N(%) shows significant improvement compared to the starting point of H10 already throughout the old curriculum. This positive trend was a second concern in merger of H to X.

The second observation is performance improvement from baseline to H14 over two first years. The first was although common to all, but still a minor improvement is shown in the second year, specific to the major. This raises a new question of performance of similar programs, such as Media Engineering.

### *C. Comparative Analysis of the Two Merged Majors*

The initial starting point of the performance analysis [2] was consideration of merging a small program into a larger. As indicated in Fig. 1, the two similar mergers occurred simultaneously in both Health Technology (H) and Media Engineering (M). A similar turnaround of indicators on both Majors can be seen in Table IV.

TABLE IV
HEALTH TECHNOLOGY AND MEDIA ENGINEERING

| | H14 Totals | | | M14 Totals | | |
|---|---|---|---|---|---|---|
| Study years | N Adm. | Avg | n/N(%) | N Adm. | Avg | n/N(%) |
| 1. Year | 39 | 53,4 | 79,5 | 29 | 56,0 | 75,9 |
| 2. Year | 39 | 56,9 | 56,9 | 29 | 56,3 | 75,9 |
| 3. Year | | | | | | |
| 4. Year | | | | | | |

Media Technology [3] was previously omitted from our analysis due to several new variables introduced, such as different campus and teaching team, among others. Analysis of the baseline performance of M using several years of data is still outside the scope of this work, and it would also require better consideration of possible changes within the program. This new comparative learning outcome gives credit to the Media Engineering in adopting the good practices or maintaining a good performance throughout the mergers. Determining this longitudinally would require further analysis of M10-M13, using the same principle as in Table III. For relevance of management actions, this seems less urgent now. We would expect to be able to report the longitudinal comparison of H, M and X after the third year.

### *D.Model Adaptation to Strategic Changes*

As shown in Fig. 2, the ICT program runs on two campuses. Initially at the beginning of the academic year 2014, nearly identical, full curricula. The most obvious differences were only the H and M Majors. During the Major selection process for Majors 2015 the other Majors were freely selectable and launched in both campuses, if requested. One such example is Game Programming in Helsinki campus (P14h) and in Espoo campus (P14e), as shown in Fig. 2. Free choice creates motivation. The success of the first year indicators was strongly considered to be motivation-related.

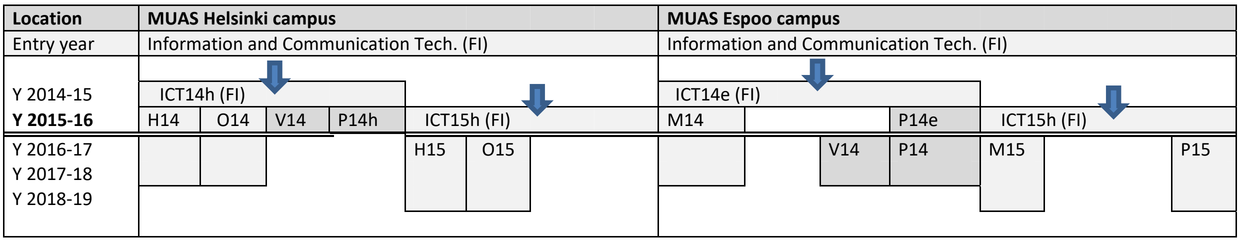


Fig. 2 Gradual discontinuation of Majors in Helsinki campus

Completely quota-free and demand-driven approach is likely to be unstable over the year and consequently result unstable, potentially inefficient or overloading resource usage. Therefore, group size quotas were introduced in 2016 selection, and study group merging between the campuses together with staff relocations were executed.

The reference model enables also a parallel comparison of the two popular Game Programming groups started initially at both campuses in as shown in Table V. In this case, no significant performance differences can be identified, because the studies were implemented using the same team of teachers. However, the working load of the team became relatively high. Therefore, and for other balancing reasons, the next year's entry started as one group only, and the Major was moved to Espoo campus.

TABLE V
GAME PROGRAMMING BY CAMPUS BEFORE MERGING

| | P14h (Admin group) | | | P14e (Admin group) | | |
|---|---|---|---|---|---|---|
| Study years | N Adm. | Avg | n/N(%) | N Adm. | Avg | n/N(%) |
| 1. Year | 31 | 54,1 | 83,9 | 38 | 50,3 | 71,1 |
| 2. Year | 31 | 52,6 | 58,1 | 38 | 54,8 | 65,8 |
| 3. Year | | | | | | |
| 4. Year | | | | | | |

Due to limited quota of entry, the student selection was based on the earned ECTS credits and grades. The effects of selection process should imply even higher motivation within the selected group. This can be reflected back to these two previous groups at the end of academic year 2017. This merging of groups is shown as a discontinuation of P14h and continuation of P14e as P14 in Fig. 2. Table V indicates slightly higher performance prior the Major selection in Helsinki. Higher results are shown in Espoo after Major selection. The relocation of staff occurred also at this time. The longitudinal follow-up through academic year of 2016-17 is likely to reveal the impact of quota setting and staff-move. These factors will be challenging to analyze quantitatively.

Another point of discontinuity in Fig. 2 is that the Networks (renamed to IoT and Cloud Computing) started at Helsinki campus (Helsinki V14 in Y 2015-16) was discontinued and moved to another campus (Espoo V14 in Y 2016-17). We expect that these two re-locations and the final discontinuation of the two remaining Majors (H and O) provide data for further factor analysis by the end of 2018. However, as with other strategic moves, the decisions have been made and from management perspective no room for actions exist. In these cases the analysis is ex-post and theoretical.

### *E. Possible Further Work*

Clearly, as shown in Fig. 2 the remaining possibility for parallel comparison within the Helsinki campus is only between Software engineering (O) and Health Technology (H). By the end of academic year (Y 2016-17) it is also possible to assess longitudinal paths of O14-O15 and H14-H15, respectively. Most likely both of the Majors are discontinued at Helsinki campus at the end of academic year 2017-18 and transferred to Espoo campus, finally completing the institutional merger of 2008 at the program level.

Another linkage between the two Majors has appeared: Software Engineering (O) provides Minor studies to Health Technology (H), and these have been strongly recommended and appeared to be somewhat attractive. There are, however challenges on the pre-requisites still. Therefore some analysis on the success of these joint learning units may be necessary. Furthermore, as described on [4] and [5], the Health Technology Major was originally built from three thematic semesters: 1) Physiological Measurement Technology; 2) Customer Oriented Software Applications; and 3) Health Technology Devices and Solutions. This relatively rigid base program has now been run through for the first time. From beginning of next academic year any one of the three thematic semesters can be replaced by another unit of engineering studies. It is still expected to be a coherent unit of study preferably from ICT or electronics, as agreed separately.

The theme 3 is heavily device-oriented. A strong need to replace it with a Health Information systems-oriented software module was raised through our close working-life recruiting needs. We are likely to analyze the implications and the potential of learning at workplace and its impact.

## IV. Conclusion

A brief introduction to the Finnish system of Universities of Applied Science highlighted the policy implementation to improve efficiency by using a revised funding model. Also the program entry structure was simplified and standardized. The paper and its related work examined the implications of the steering on an educational program level.

The paper provides a practical and managerial perspective to re-establish understanding of the program performance on a new funding situation by applying the new funding criteria retrospectively into the historical data. This practical approach established program performance baselines prior the reform in a comparable form. Applying the same criteria after the reform enabled also longitudinal comparison to identify their development trends. Causal relationships and their factor analysis are outside the scope of the paper.

The paper observes learning outcome as registered ECTS grades. Obviously this view is very administrative and omits the obtained skills and competences in qualitative sense. The use of performance indicators implicitly includes an assumption that although the system level steering contains strong elements of pressure down to a study group and student level, this has no effect on individual grading decisions. However, this implication is to be noted and it is suggested that it will remain in the institutional and program management role to suppress the steering pressure before it reaches individual level. Preferably, the performance indicators provide a tool to locate best team teaching and learning practices and targets of support.

It is likely that we follow up the process until the completion of the new curricula. This work considered also the applicability of the used indicators in a quickly changing strategic program and campus changes. It is expected that the indicators are applicable under such circumstances. In further work, also in anticipation that we collect more data systematically, it seems feasible to introduce a limited number of new, perhaps campus-related factors to explain possible differences.

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