Restructuring the programme and integrating streams in an undergraduate health care programme to enhance applied and life-long learning

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The intervention

This project involves an undergraduate programme in radiography which is aimed to produce a professional with the theoretical knowledge, understanding and competence to practice as a graduate radiography, by providing an academically challenging and vocationally relevant education. It is a 3-year programme. The captioned programme has a size of approx. 40 students in every year of the programme at any particular point of time. The duration of the intervention is 2 years.

The intervention is updating and restructuring the entire curriculum of existing undergraduate programme on radiography to address various emerging and dynamic issues as set out in the section below. Such issues have made the existing programme looked to be outdated, the contents appeared to be insufficient, and individual modules in our programme seemed to be overlapping with the others.

Being a major restructuring of the programme, changes take place in several areas. In addition, this intervention involves re-designing of teaching and learning activities in different individual subjects. This report explains the intervention as follows. Part I is about the whole programme. Part II is an example about aligning teaching and assessment with outcomes in a particular subject in the programme. Part III is the evaluation of impacts on students' approaches to studying. Closing remarks are offered before the end of the report.

Part I: The Programme Restructuring

Section A: Overview of the Restructuring

Context

What was the driving force behind this intervention?

The main driving force behind this intervention comes from several sources as follows.

1. The programme involves a great deal of technology. With many technology-related subjects in the programme, the contents of all technology-related subjects need to be aligned with the progression of the rapidly developing technology in this modern era.

2. The incoherence between theory and practice presents needs to undergo programme development to bridge the gap between theory and practice and to relate technology subjects with clinical subjects.

3. The government through the UGC allocated a fixed number of students to our B.Sc. in Radiography programme on the understanding that Medical Imaging and Radiation Therapy would not be separate streams within the programme. Such constraint presents ongoing pressure to have the separate streams to be integrated.

As a result, our existing programme looked to be outdated, the contents appeared to be insufficient, and individual modules in our programme seemed to be overlapping with the others.

The concept of constructive Alignment is employed as a guiding principle throughout the curriculum restructuring of this programme. The whole process of curriculum restructuring involves several aspects of review and development. These aspects support each other to achieve constructive alignment. They are summarised diagrammatically below.

Re-formulating programme aims and learning objectives for a fully contemporary and vibrant curriculum in radiography

Programme aims (of the ultimate integrated programme)

Upon completion of the entire exercise, the programme is aimed to produce professionals who are familiar with the contemporary developments in the field of radiography. As such, they should be proficient in knowledge of and skills in employing both the modern and traditional technology in clinical situations. These professionals possess both the theoretical and practical knowledge, including the application of theory in their clinical practices. In addition, they are expected to be able and have the vision to integrate the knowledge of medical imaging and radiation therapy.

Learning outcomes

In addition to other programme outcomes, upon graduation from the programme, students will also be able

a) To operate medical imaging equipments involving modern-era technology
b) To employ both modern digital imaging technology and traditional imaging technology where appropriate
c) To apply theory and technology in radiography effectively in clinical situations in practice
d) To relate medical imaging and radiation therapy in different clinical situations

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Re-structuring the content ▪ Include the rapidly developing technology of digital imaging in this modern era in the content of the programme ▪ Strike a rightful and reasonable balance between digital imaging technology and conventional imaging method ▪ Avoid overlapping in teaching in different subjects taught by different faculty members ▪ Rearrange the sequence of subjects in the programme so that students would experience a logical progression across subjects in the course of their study ▪ Offer ample opportunities to apply radiography theory in clinical situations ▪ Integrate the two different streams, i.e., Medical Imaging and Radiation Therapy, in our B.Sc. in Radiography programme, in response to institutional pressure	➔	**Re-designing the teaching and assessment of the subjects** Implement constructive alignment through curriculum development for the entire programme and through new and more appropriate teaching / learning activities and assessment methods in specific subjects The re-designing process includes: ▪ reducing didactic lectures ▪ enhancing interaction ▪ including case studies ▪ employing assessment methods to align with the learning outcomes and to emphasize ability to integrate learning among different topic areas of the subjects ▪ Collecting interim feedback from students

Section B: A 3-Focus Programme Restructuring Process

This section outlines the shortcomings of the programmes with reference to various aspects leading to the restructuring process the recent developments of the intervention

The former curriculum

The current B.Sc. in Radiography programme has already been offered in the department of optometry and radiography for a number of years before this current constructive alignment intervention. The minimum programme is of three academic years, with three stages lasting one year each: stage one consists of 28 weeks at PolyU; stage two consists of 28 weeks at PolyU plus 6 weeks of clinical placement between the two semesters; stage three consists of 16 weeks at PolyU plus 6 weeks of clinical placement in each of the two semesters.

Students would choose either one of the streams between Medical Imaging and Radiation Therapy. Stage one is basically common to both streams, in which foundations are studied. Stages two and three are divided into common subjects and professional specialities, which are mutually exclusive between the two streams.

Structure of the old curriculum for students entering the programme in the 2002-2003 academic year

Shortcomings of the programme leading to the restructuring of the programme

As captioned previously in section A, various shortcomings of the former programme have been observed. As a result, such shortcomings triggered some driving forces to restructure the programme. To elaborate, we have summarized the shortcomings as follows.

In this modern era, the technology of digital imaging has been rapidly developing. Such development is pivotal to medical imaging, as demand for digital imaging is expected to be increasing significantly in the near future. Meanwhile, the conventional radiographic imaging method could neither be overlooked nor abandoned, as it should be indispensable and many medical facilities would continue to use the traditional method for various reasons. Such circumstance presents a dilemma to numerous medical imaging programmes.

In addition, there were some complaints received from students from time to time regarding the structure of the programme. First, students complained that the contents of certain subjects overlap with others. Thus they would often get confused in the overlapping modules in the course of their study. There were also complaints from students that the timing of the learning of technology in the programme was quite incoherent with the applications of such technology in other subjects. It was not unusual that they would forget the technology which was supposedly learnt earlier in the programme when they actually had to apply them. Nevertheless, it is essential that all our graduates must have a comprehensive understanding of associated technologies and their role within the clinical context.

From the teaching perspective, there were too many didactic lecture hours in the programme in which student just copied notes on the projector. In this mode, teaching and learning were not interactive and there was too little interim feedback from students during the semester. In addition, the programme team has been facing tremendous institutional pressure to integrate the two streams in our programme. Yet, despite all these ongoing issues such that the former programme had been rapidly becoming insufficient in this modern era, some faculty members were resistant to changes and modifications.

Focus 1: Restructuring the content of the programme (mainly implemented in the 2003-2004 academic year)

In the 2003-2004 academic year, the programme team began the restructuring by considering the changes in technology, the overlapping of our subjects and the logical sequence of subjects in the programme. As a result, we concluded that a rightful balance between digital imaging and radiographic imaging, a restructured content and a rearranged sequence of subjects should be the benchmark for our programme. The programme team decided that the restructuring began for year 1 students in the 2003-2004 academic year only, so that other students already studying in the programme, essentially those year 2 and year 3 students, wouldn't be overwhelmed.

The most paramount issue was to ensure that students would have learned the digital imaging in year 1. As such, students would have acquired a proper background prior to their study in later years. This focus was critical in the sense that once students got the foundation in digital imaging, they could pursue further studies in other advanced subjects related to CT and MRI with no problems like what their senior cohorts had experienced in the past. The restructured programme features a logical sequence of learning modules and removal of duplication of contents in different subjects. As a result, students would be able to relate various technology subjects to the others and have progressive development while learning within the course of the programme.

Although mainly implemented in the 2003-2004 academic year, the rearrangement of the sequence continued in the 2004-2005 academic year. For instance, in the 2004-2005 academic year, two subjects, Equipment for Medical Imaging (OR375) and Quality Assurance for Medical Imaging (OR373), which were supposedly parts of the study for year 2 students, would be phased out completely. Instead, students would take Principles of Imaging and Equipment III and Principles of Imaging and Equipment IV in the rearranged programme.

Focus 2: Bridging the gap between theory and practice and relate technology subjects with clinical subjects (mainly in the 2004-2005 academic year)

As there were complaints from students that the timing of the learning of technology in the programme was quite incoherent with the applications of such technology in other subjects, the programme team identified that there was a gap between theory and practice. The technology subjects learnt by our students earlier in the programme were not adequately related to the clinical subjects they would learn in the later stage of the programme. Such gap hindered the professional development of our students as they tended to forget the technology which was supposedly learnt earlier in the programme when they actually had to apply them. We decided to bridge such gap between theory and practice.

The focus here is to relate the technology subjects into the overall development of students learning in the programme. The first move in this focus was at the start of the project. We closely reviewed the technology subjects themselves to provide a more coherent development. We have made the decision to bring technology and clinical subjects together into a single subject with the aim of further enhancing the relation between them. As such, the programme team teaches clinical subjects with expected stages of learning having already been developed for technology related areas. In addition, there is an increased focus on laboratory/tutorial based learning rather than the previous emphasis on lectures in various subjects.

Focus 3: Integrating the two streams of the programme so that a fully contemporary and vibrant programme is to be introduced in the 2005-2006 academic year

As we have discussed previously, the government through the UGC has allocated a fixed number of students to our B.Sc. in Radiography programme on the understanding that medical imaging and radiation therapy would not be separate streams within our programme. Therefore we have been required to integrate the two streams in our programme. In doing so, it becomes single programme without streams and yet maintain the integrity of both professional groups to the degree that both groups will be able to gain professional registration upon graduation.

Such integration will be completed in time before the beginning of the 2005-2006 academic year. By then, a fully contemporary and vibrant programme will be introduced. This programme features 1. Early introduction to digital imaging; 2. No overlapping of contents in separate courses; 3. A logical progression across subjects; 4. A understandable relation between technology subjects and clinical subjects; and 5. An integration of medical imaging and radiation therapy streams.

In this new programme, even with fewer credits in the entire programme (decreased from 108 in the old curriculum to 90 in the updated programme), students would learn non-overlapping content in logically sequenced modules. Also, upon graduation, they possess skills properly match the job requirements from employers in this modern era.

Structure of the new curriculum for students entering the programme in the 2005-2005 academic year

Part II: Re-designing a subject –
Principles of Imaging and Equipment I (PIE I)

Section A: Overview of the Subject

→ **Teaching & Learning**	**Intended Learning Outcomes**	← **Assessment**
Lectures supported by tutorials and practical classes	a) discuss the factors involved in the construction of diagnostic X-ray tubes b) operate X-ray equipment and other accessories appropriately to produce radiograph and to carry out an experimental study c) observe safe practice in radiation area d) explain the process of image information using conventional radiographic imaging and fluoroscopic equipment e) understand the process of film development and be able to operate and manage the quality control of an automatic processing unit f) evaluate the elements comprising the radiographic image and demonstrate the practical expertise to control these elements g) evaluate and criticise the performance of different film emulsions and intensifying screens using sensitometric and resolution tests h) compare and evaluate the quality of images when different exposure conditions are used i) compare and contrast the imaging process in computed radiography with conventional radiographic imaging j) communicate effectively the process and outcome of an experimental study	Film evaluation Laboratory report Essay
	In formulating these outcomes, we try to: - Introduce students to the rapidly developing technology of digital imaging in this modern era - Strike a rightful and reasonable balance between digital imaging technology and conventional imaging method - Acquaint students with necessary skills and knowledge to undertake subsequent modules in the programme - To keep our radiography programme contemporary	

Mapping Learning Tasks to Outcomes

Intended Learning Outcomes	Teaching & Learning	Assessment
a) discuss the factors involved in the construction of diagnostic X-ray tubes	▪ Lectures supported by tutorials and practical classes	▪ Laboratory report
b) operate X-ray equipment and other accessories appropriately to produce radiograph and to carry out an experimental study	▪ Lectures supported by tutorials and practical classes	▪ Laboratory report

c) observe safe practice in radiation area	▪ Lectures supported by tutorials and practical classes	▪ Laboratory report
d) explain the process of image information using conventional radiographic imaging and fluoroscopic equipment	▪ Lectures supported by tutorials and practical classes	▪ Film evaluation
e) understand the process of film development and be able to operate and manage the quality control of an automatic processing unit	▪ Lectures supported by tutorials and practical classes	▪ Film evaluation
f) evaluate the elements comprising the radiographic image and demonstrate the practical expertise to control these elements	▪ Lectures supported by tutorials and practical classes	▪ Film evaluation ▪ Laboratory report
g) evaluate and criticise the performance of different film emulsions and intensifying screens using sensitometric and resolution tests	▪ Lectures supported by tutorials and practical classes	▪ Film evaluation ▪ Laboratory report
h) compare and evaluate the quality of images when different exposure conditions are used	▪ Lectures supported by tutorials and practical classes	▪ Film evaluation ▪ Laboratory report
i) compare and contrast the imaging process in computed radiography with conventional radiographic imaging	▪ Lectures supported by tutorials and practical classes	▪ Essay
j) communicate effectively the process and outcome of an experimental study	▪ Lectures supported by tutorials and practical classes	▪ Laboratory report

Section B: Aligning Teaching and Assessment with Outcomes

This section explains how constructive alignment is achieved with the chosen teaching, learning and assessment methods in the programme

Teaching and Learning Methods

- **Lectures supported by tutorials and practical classes**

All learning outcomes are to be achieved by students through lectures supported by tutorials and practical classes. Thus such teaching and learning activities are aligned with the intended learning outcomes explicitly set to promote constructive alignment. The lectures, tutorials and practical classes are thoughtfully and carefully sequenced to support the attainment of the set of learning outcomes, however identical. Typically, while focusing on the same concepts and knowledge, tutorials and practical classes are scheduled about one week behind the lectures. The idea is to pinpoint the dilemma typically faced in lectures – a lot of concepts are introduced, yet time insufficiency prevents to go into detail. The arrangements are as follows.

- Concepts and overviews are introduced in lectures and reinforced in practical classes. In other words, lectures and practical classes are related so that lectures would serve the purpose of giving first introduction, whilst practical classes would serve the purpose of acquiring some experience and practical work. In this way, the gap between theory and practice is bridged.

- Teaching and learning methods aim to bring technology and clinical elements of the subject together. Digital imaging technology has been included as part of the lecture outline. As a result, students are introduced to such modern era technology early in their study.

- Meanwhile, conventional imaging method is covered as before. As such, we strike a rightful and reasonable balance between digital imaging technology and conventional imaging method.

- In addition, mini case-based learning is employed in tutorials. For example, the case can be a radiograph so that students are given opportunities to describe what have been observed and explain the observation. Students find such activities in tutorials interesting and fruitful, as time is in general insufficient in lectures for students to be engaged in such exercise, so that elaboration on any concepts and overviews is almost impossible.

- The radiography example above notwithstanding, the cases adopted in the mini case-based learning are real-life so that real products are shown. Therefore, they are complimentary to the lectures and related to the professional subjects.

- A sample of the mini case-based learning exercise in one PIE I tutorial.

Assessment Methods

❖ **Overview**

This subject, PIE I, employs multiple formal assessment methods. They are employed variously and fittingly to assess the wide range of intended learning outcomes and the extent to which they have been achieved. Each method aims to assess the achievement of different outcomes, as per the mapping illustrated above. Thus such assessment methods are aligned with the intended learning outcomes explicitly set to promote constructive alignment. The assessment methods include film evaluation, laboratory report and essay. Each assessment method is elaborated as follows.

❖ **Film evaluation**

Film evaluation is the assessment method for tutorials. Tutorials allow time and give opportunities for students to examine radiographic images thoroughly, which have been introduced in lectures earlier. In this assessment method, students would be given several cases of radiographic images. They are requested to analyse and evaluate the photographic quality of the films. Students are expected to:

- Demonstrate an understanding of the interrelationship among exposure factors selection, film latitude and exposure latitude.
- Explain how exposure parameter may affect the contrast, resolution and noises.
- Identify the common artifact seen in conventional radiographic imaging and be able to explain the causes and suggest remedies.

In doing so, the achievements of learning outcomes d), e), f), g) and h) have been assessed.

❖ **Laboratory report**

Laboratory report is the assessment method for practical classes. Similar to tutorials, these practical classes are thoughtfully scheduled behind lectures so that students have been introduced to the related concepts in lectures prior to these practical classes. These practical classes allow students the opportunities to bridge the gap between theory and practice. Students are required to present their results of their practical works with panel discussion. For such purpose, students have to submit reports which are expected to:

- Demonstrate an understanding and integration of the underpinned concepts and theories.
- Appraise contentious issues critically.
- Present the ideas and relevant contents logically and with a pertinent conclusion.
- Accurately use language and literature and properly use referencing.

The format of the report should use the IMRAD formula as the layout. That is, it includes sessions on introduction, methodology, results and discussion, as well as a conclusion. As such, a wide range of learning outcomes has been assessed, particularly j).

❖ **Essay**

An essay, which should be word processed with word limit between 700-1000, titled "Can conventional radiography be replaced by computed radiography?" is to be written and be part of the assessment. As discuss previously, this subject and the entire programme attempt to strike a rightful and reasonable balance between digital imaging technology and conventional imaging method, as both methods are essential in this modern era.

In this assessment method, students are given opportunities to compare and contrast the two methods. As a result, students would be able to demonstrate their understanding of the similarities and differences between these two methods. This essay also could shed light on the strengths and weaknesses of the two methods.

Students need to read the literature in this area and make comparisons of the two in terms of the image quality, radiation dose reduction, and image processing. From the discussion, students should make conclusions that answer the question posed.

In doing so, the achievement of learning outcome i), i.e., compare and contrast the imaging process in computed radiography with conventional radiographic imaging, is comprehensively assessed.

The grading descriptions for the essay

- **Mini case-based learning exercises**

The mini case-based learning exercises in the tutorials are not formally assessed. They serve as formative assessments since they are complimentary to the lectures.

Part III: Evaluation

This section contains a summary of the evaluation methods and the results obtained. As a closing remark to this sharing, the authors talk about the insights he gets in this experience of introducing constructive alignment into his curriculum.

Evaluations

Evaluation of impacts on students' approaches to studying

- **Methodology**

To measure students' approaches to studying, a 20-questions Study Process Questionnaire (SPQ) is employed. Students reveal their agreement to every on a 5-point scale. Essentially, these 20 questions measure 4 factors, namely deep motive, deep strategy, surface motive, and surface strategy, of students' approaches to studying. The sum of every student's deep motive and deep strategy scores become the deep approach score; so the sum of every student's surface motive and surface strategy scores become the surface approach score. The implications of the two approaches to studying are as follows:

Deep Approach – intrinsic interest in learning, prone towards pursuit of understanding
Surface Approach – exam-oriented, prone towards rote learning

It is hypothesized that a curriculum in constructive alignment encourages deep approach to studying and discourages surface approach to studying. As such, a constructive alignment intervention during the course of study, say one semester or one academic year, could increase students' deep approach scores and decrease their surface approach scores. Such changes should be reflected by the differences in pre-test and post-test scores. The impact on students' approach to studying is therefore indicative of the extent that constructive alignment has been achieved.

As depicted, the Study Process Questionnaire (SPQ) was used as the instrument for measuring student approaches to studying. The questionnaire was administered at two points over the period of implementation so that changes in student approaches to studying over time can be recorded. Thus the data obtained at the two different points essentially would become pre-test and post-test data over one academic year in which constructive alignment has been implemented. The differences between scores were computed to represent the changes over time. Such changes can be either longitudinally examined using a statistical procedure (by a paired-sample *t*-test) within the sample or compared with another sample obtained from another class who have not experienced the constructive alignment intervention (i.e., a control group) using a statistical procedure (by an independent samples *t*-test).

- **Findings and discussion (2003-2004 academic year)**

Data and the study

Study Process Questionnaire (SPQ) was administered at the beginning and the end of the 2003-2004 academic year for both year 1 and year 2 students in the programme. Data collected at the beginning of the academic year, on 18 Sep 03, for both groups of students are classified as 'pre-test' and data collected at the end of the academic year, on 22 April 04, for both groups of students are classified as 'post-test'.

For the pre-test, 43 year 1 students and 32 year 2 students participated. For the post-test, 36 year 1 students and 32 year 2 students participated. Data for students who did not participate in either the pre-test or the post-test are deleted. Likewise, students who submitted incomplete responses in either the pre-test or the post-test are excluded. Such stringent procedures yield a paired-sample of 36 observations for the YR1 group and another paired-sample of 31 observations for the YR2 group. The two groups are denoted 'Radiography programme 2003 YR1' and 'Radiography programme 2003 YR2' respectively.

As discussed in the curriculum development section, the 2003-2004 academic year represents the first year of implementation of the present constructive alignment intervention. Naturally, the intervention began at the year 1 level such that the 36 observations of year 1 students would comprise an experimental group. Meanwhile, year 2 students follow the existing curriculum under which they had begun their study as year 1 students in the 2002-2003 academic year. As illustrated previously, the 2002-2003 academic year was the last year of the old curriculum. Therefore, such year 2 students would comprise a control group accordingly. As we are interested to investigate the impacts of the present intervention on students' approaches to studying, the two groups' pre-test and post-test differences are investigated respectively. Thereafter, the experimental group is to be compared with their year 2 counterparts, the control group, to check if there are significant differences between these two groups, who have undergone their programmes different.

To conduct thorough investigation regarding the intervention, we are interested to compare the impacts on the experimental group, i.e., the pre-test and post-test differences, against those recorded in other control groups. For this purpose, a control group, denoted 'Control' is called upon for comparison. Such data were collected in Semester 1 of the 2003-2004 academic year. The control group contains undergraduate students only, from various departments at PolyU.

Further, there are students from the OR department in this control group. These students who participated in the OR control group were from the course OR207 in the 2003-2004 academic year. As such, another control group, named 'Control OR only', containing these students only, is compared against the experimental groups in our current investigation.

For all groups, the same stringent procedures apply: observations with incomplete responses in either the pre-test or the post-test are omitted. Respondents who are absent from either the pre-test or the post-test also are omitted. These procedures yield a paired-sample of 36 observations [Radiography programme 2003 YR1], 31 observations [Radiography programme 2003 YR2], 164 observations [Control] and 32 observations [Control OR only] respectively.

Individual changes (YR1 = experimental group vs. YR2 = control group)

We would like to investigate the changes in scoring of the learning approach variables, deep approach, deep motive, deep strategy, surface approach, surface motive and surface strategy for the each person. That means we want to test whether the individual changes in each variable are statistically significant.

Paired-sample *t*-tests were carried out to examine the difference between the pre-test and post-test scores on each of the two factors and each of the four sub-factors measured by the questionnaire. Results, hypotheses and statistical significance for both the YR1 and YR2 students are reported as follows.

Radiography programme 2003 YR1 (Experimental Group)	**Paired-sample size**	**Mean scores**		**t-statistic**	**Significance**
		Pre-test	Post-test		*p value*
Deep Approach	**36**	**30.42**	**29.42**	**-1.14**	**0.26**
Deep Motive	36	15.00	14.47	-0.87	0.40
Deep Strategy	36	15.42	14.94	-1.03	0.31
Surface Approach	**36**	**25.31**	**28.06**	**2.73****	**0.01**
Surface Motive	36	11.56	13.72	3.90***	0.00
Surface Strategy	36	13.75	14.33	1.02	0.32

Radiography programme 2003 YR2 (Control Group)	Paired-sample size	Mean scores		t-statistic	Significance
		Pre-test	Post-test		*p value*
Deep Approach	**31**	**28.10**	**25.68**	**-2.91*****	**0.01**
Deep Motive	31	14.39	12.84	-2.53**	0.02
Deep Strategy	31	13.71	12.84	-2.08**	0.05
Surface Approach	**31**	**28.32**	**31.55**	**2.99*****	**0.01**
Surface Motive	31	13.58	15.65	3.19***	0.00
Surface Strategy	31	14.74	15.90	2.10**	0.04

The null hypothesis and alternative hypothesis are:
H_0: Pre-test score = Post-test score;
H_1: Pre-test score ≠ Post-test score (two-tail test).

Asterisk: *, **, and *** denote the difference is statistically different from 0 at the 10%, 5%, and 1% levels respectively

As illustrated, the differences between the students' 'deep' means are relatively subtle, though with a rather consistent decreasing pattern during the time lapsed between the pre-test and the post-test, and statistically insignificant all across the board. On the other hand, the differences between the students' 'surface' means are all positive, i.e., all means recorded in the post-test are higher than that recorded in the pre-test. In addition, two differences are highly significant; one at the 1% level while another at the 5% level.

For the YR2 student, all 'deep' scores have decreased and all differences are statistically significant at various levels. Meanwhile, all 'surface' scores have increased and all differences are statistically significant at various levels too. Relatively speaking, results are quite encouraging for the year 1 students following the constructive alignment implementation.

Comparisons with control groups

To contrast students' changes approaches, motives and strategies to study in the experimental group with respect to the YR2 cohorts, the control group, and other control groups, the experimental group of Radiography programme students is compared against the 'Radiography programme 2003 YR2' cohorts, the 'Control' and the 'Control OR Only'.

To begin our comparisons, some statistics, together with the hypotheses and statistical significance of the two additional control groups are reported as follows:

Control	Paired-sample size	Mean scores		t-statistic	Significance
		Pre-test	Post-test		*p value*
Deep Approach	**164**	**32.16**	**31.98**	**-0.51**	**0.61**
Deep Motive	164	15.88	16.08	0.95	0.34
Deep Strategy	164	16.27	15.90	-1.78*	0.08
Surface Approach	**164**	**25.84**	**29.18**	**8.73*****	**0.00**
Surface Motive	164	12.14	14.18	8.72***	0.00
Surface Strategy	164	13.70	14.99	6.06***	0.00

Control OR Only	**Paired-sample size**	**Mean scores**		**t-statistic**	**Significance**
		Pre-test	Post-test		*p value*
Deep Approach	**32**	**31.50**	**30.66**	**-1.27**	**0.21**
Deep Motive	32	15.50	15.06	-1.06	0.30
Deep Strategy	32	16.00	15.59	-0.93	0.36
Surface Approach	**32**	**26.22**	**28.38**	**3.68*** **	**0.00**
Surface Motive	32	12.38	13.94	4.22***	0.00
Surface Strategy	32	13.84	14.44	1.49	0.15

The null hypothesis and alternative hypothesis are:
H_0: Pre-test score = Post-test score;
H_1: Pre-test score ≠ Post-test score (two-tail test).

Asterisk: *, **, and *** denote the difference is statistically different from 0 at the 10%, 5%, and 1% level respectively.

Difference of Means

With the above findings in mind, for the six variables for the two additional control groups, the differences between pre-test and post-test scores are computed. A positive reading indicates that the post-test score is higher than the pre-test score, and vice versa. These four independent samples, i.e., 'Radiography programme 2003 YR1', 'Radiography programme 2003 YR2', 'Control' and 'Control OR only' are variously tested against the others. *All 'Differences' = 'post-test score – pre-test score'*. Additional t-tests are employed to test such differences. Results, hypotheses and statistical significance are reported as follows.

Radiography programme Between-Cohort Comparisons (YR1 = the experimental group; YR2 = the control group)

Radiography programme 2003 Different Cohorts	**Sample size**	**Mean difference**		**t-statistic**	**Significance**
	YR1/YR2	YR1	YR2		*p value*
Deep Approach Difference	**36/31**	**-1.00**	**-2.42**	**-1.17**	**0.25**
Deep Motive Difference	36/31	-0.53	-1.55	-1.18	0.24
Deep Strategy Difference	36/31	-0.47	-0.87	-0.64	0.53
Surface Approach Difference	**36/31**	**2.75**	**3.23**	**0.32**	**0.75**
Surface Motive Difference	36/31	2.17	2.06	-0.12	0.91
Surface Strategy Difference	36/31	0.58	1.16	0.72	0.47

The null hypothesis and alternative hypothesis are:
H_0: Radiography programme 2003 YR1 pre-test & post-test difference = Radiography programme 2003 YR2 pre-test & post-test difference;
H_1: Radiography programme 2003 YR1 pre-test & post-test difference ≠ Radiography programme 2003 YR2 pre-test & post-test difference (two-tail test).

Radiography programme 2003 YR1 vs. Control

Radiography programme 2003 YR1 vs. Control	Sample size	Mean difference		t-statistic	Significance
	YR1/Control	YR1	Control		*p value*
Deep Approach Difference	**36/164**	**-1.00**	**-0.18**	**0.97**	**0.33**
Deep Motive Difference	36/164	-0.53	0.20	1.39	0.17
Deep Strategy Difference	36/164	-0.47	-0.37	-0.20	0.84
Surface Approach Difference	**36/164**	**2.75**	**3.34**	**0.63**	**0.53**
Surface Motive Difference	36/164	2.17	2.04	-0.22	0.83
Surface Strategy Difference	36/164	0.58	1.30	1.35	0.18

The null hypothesis and alternative hypothesis are:
H_0: Radiography programme 2003 YR1 pre-test & post-test difference = Control pre-test & post-test difference;
H_1: Radiography programme 2003 YR1 pre-test & post-test difference ≠ Control pre-test & post-test difference (two-tail test).

Radiography programme 2003 YR1 vs. Control OR Only

Radiography programme 2003 YR1 vs. Control OR Only	Sample size	Mean difference		t-statistic	Significance
	YR1/Ctrl OR Only	YR1	Ctrl OR		*p value*
Deep Approach Difference	**36/32**	**-1.00**	**-0.84**	**0.14**	**0.89**
Deep Motive Difference	36/32	-0.53	-0.44	0.12	0.91
Deep Strategy Difference	36/32	-0.47	-0.41	0.10	0.92
Surface Approach Difference	**36/32**	**2.75**	**2.16**	**0.49**	**0.62**
Surface Motive Difference	36/32	2.17	1.56	-0.88	0.38
Surface Strategy Difference	36/32	0.58	0.59	0.02	0.99

The null hypothesis and alternative hypothesis are:
H_0: Radiography programme 2003 YR1 pre-test & post-test difference = Control OR only pre-test & post-test difference;
H_1: Radiography programme 2003 YR1 pre-test & post-test difference ≠ Control OR only pre-test & post-test difference (two-tail test).

Asterisk: *, **, and *** denote the difference is statistically different from 0 at the 10%, 5%, and 1% level respectively.

As illustrated and denoted, generally speaking the results were more encouraging for the Radiography 2003 YR1 students (with the constructive alignment intervention) than their year 2 cohorts and other control groups, though most of the differences were statistically insignificant. One possible reason was that the intervention was still too brief to have more significant impacts recorded then. Nevertheless, early results have been quite promising indeed.

- **Findings and discussion (2004-2005 academic year)**

Data and the study

Study Process Questionnaire (SPQ) was administered again in the 2004-2005 academic year. Similarly, both year 1 and year 2 students participated in the survey. As recalled, the year 1 students in the 2003-2004 academic year, the only ‘experimental group’ then, naturally have become year 2 student in the 2004-2005 academic year. Besides, as depicted in the 3-focus programme restructuring process section, the year 1 students in the 2004-2005 academic year, those students newly admitted to the programme, also are the subjects of the intervention. Thus, both the year 1 and year 2 students in the 2004-2005 academic years are experimental groups in this year. They are denoted ‘Radiography programme 2004 YR1’ and ‘Radiography programme 2004 YR2’ respectively.

During the captioned academic year, there were 3 data collection points regarding students' approaches to studying. One in the beginning of the academic year, one about in between of the two semesters, and one at the end of the academic year. They constitute the pre-test, interim test, and post-test data collection points.

For the pre-test, 30 year 1 students and 27 year 2 students participated. For the interim test, 23 year 1 students and 24 year 2 students participated. For the post-test, 29 year 1 students and 26 year 2 students participated. Similar to previous procedures, for the year 1 students, data for students who did not participate in either the pre-test, the interim test or the post-test are deleted. Likewise, year 1 students who submitted incomplete responses in either test are excluded. Such stringent procedures yield a paired-sample of 22 observations for the YR1 group.

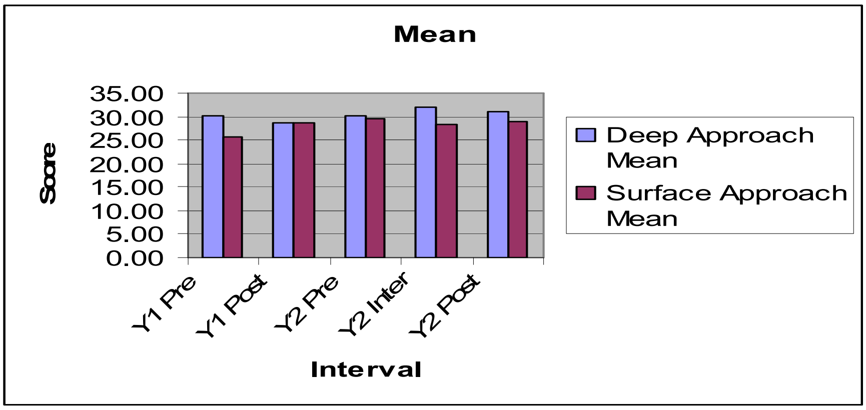
For the year 2 students, recall that the intervention began when they were year 1 students during the 2003-2004 academic year. As such, collectively with the data collected one year ago, there are 5 data collection points for the longitudinal analysis. We are interested to investigate the changes, if any, regarding students' approaches to studying during every interval of the 5 data collection points in the 2-year span. To investigate that, data for students who did not participate in either one of the tests during the 2-year span are deleted. Likewise, students who submitted incomplete responses in either test are excluded. Such stringent procedures yield a paired-sample of 18 observations for the YR2 group.

Individual changes (YR1 in the 2003-2004 academic year to YR2 in the 2004-2005 academic year)

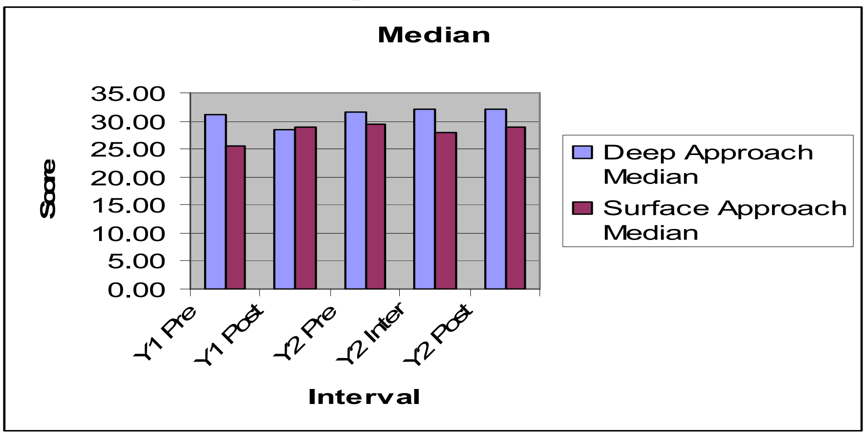
We begin our investigation with a longitudinal analysis of the paired sample of 18 students who were year 1 students during the 2003-2004 academic year and promoted to year 2 students during the 2004-2005 academic year. They have undergone 2 years of the CA intervention. We like to document the changes in their approaches to studying, as recorded in the 5 different data collection pints, i.e., Y1 pre-test, Y1 post-test, Y2 pre-test, Y2 interim test, and Y2 post-test, during the 2-year span, if any, with respect to the CA intervention.

We plot both the deep approach and surface approach means and the deep approach and surface approach medians, against the 2-year span, to observe the trend, if any, of the two approaches to studying. Scores are plotted as follows.

'Deep' vs. 'Surface'



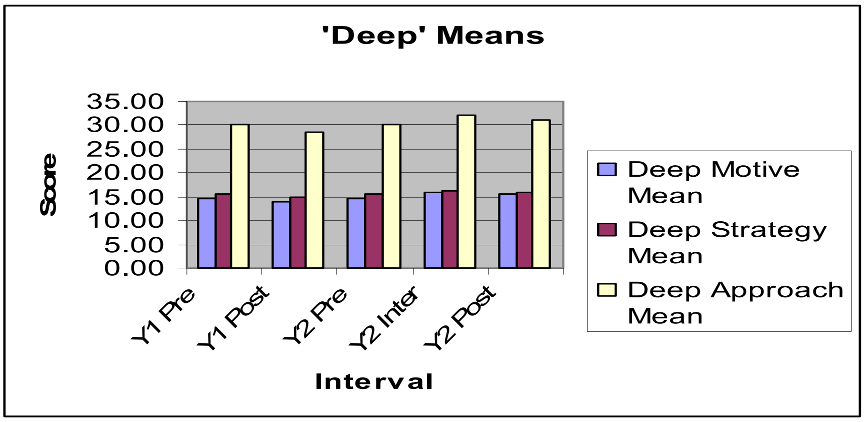
'Deep' vs. 'Surface'

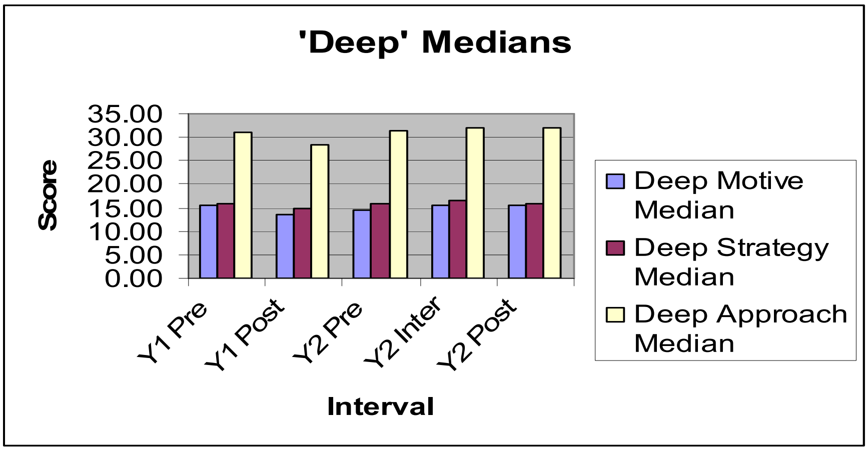


Deep approach scores seem to be high at the beginning, then drop a bit in the end of year 1, but rebound in year 2. Such results coincide with the departure of several faculty members at the end of the 2003-2004 academic year. The personnel of the programme has been stabilised since then. Surface approach scores appear to have an increasing trend, similar as per the observation in other sub-projects under the present study.

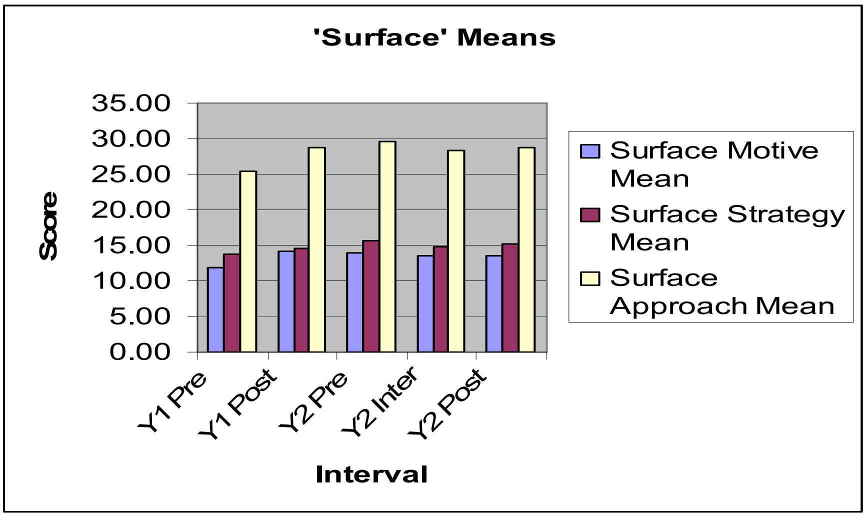
To scrutinize the deep approach and the surface approach separately and more thoroughly, the breakdown of them are plotted against time as follow.

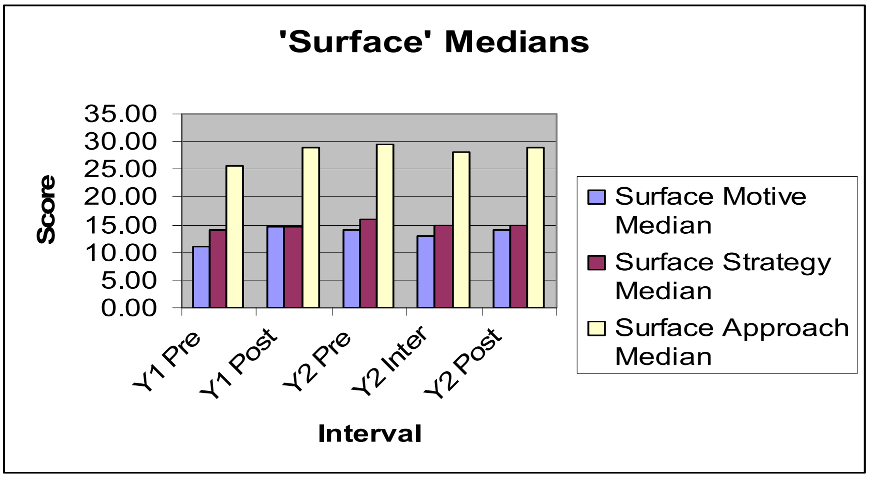
Analysis of the trend of 'deep' scores





Analysis of the trend of 'surface' scores





We investigate this paired-sample of 18 students, denoted 'Radiography programme 2003&2004 YR1-2' further. Paired-sample standard t-tests were carried out to examine the difference in scores between all intervals on the two factors and four sub-factors measured by the questionnaire. Results, hypotheses and statistical significance for this sample, during their study from Year 1 in the 2003-2004 academic year to Year 2 in the 2004-2005 academic year are reported as follows.

Radiography Programme	**Paired-sample**	**Mean scores**		**t-statistic**	**Significance**
2003&2004 YR1-2	Size	Pre-test Yr 1	Post-test Yr 1		*p value*
Deep Approach	**18**	**30.06**	**28.61**	**-1.15**	**0.27**
Deep Motive	18	14.61	13.78	-1.03	0.32
Deep Strategy	18	15.44	14.83	-0.92	0.37
Surface Approach	**18**	**25.50**	**28.72**	**2.51****	**0.02**
Surface Motive	18	11.83	14.17	2.98***	0.01
Surface Strategy	18	13.67	14.56	1.19	0.25

Radiography Programme	**Paired-sample**	**Mean scores**		**t-statistic**	**Significance**
2003&2004 YR1-2	Size	Post-test Yr 1	Pre-test Yr 2		*p value*
Deep Approach	**18**	**28.61**	**30.28**	**2.78****	**0.01**
Deep Motive	18	13.78	14.72	2.97***	0.01
Deep Strategy	18	14.83	15.56	1.40	0.18
Surface Approach	**18**	**28.72**	**29.67**	**0.85**	**0.41**
Surface Motive	18	14.17	14.00	-0.27	0.79
Surface Strategy	18	14.56	15.67	1.68	0.11

Radiography Programme 2003&2004 YR1-2	Paired-sample	Mean scores		t-statistic	Significance
	Size	Pre-test Yr 2	Interim Yr 2		*p-value*
Deep Approach	**18**	**30.28**	**32.11**	**2.23****	**0.04**
Deep Motive	18	14.72	15.89	2.54**	0.02
Deep Strategy	18	15.56	16.22	1.19	0.25
Surface Approach	**18**	**29.67**	**28.39**	**-1.14**	**0.27**
Surface Motive	18	14.00	13.50	-0.69	0.50
Surface Strategy	18	15.67	14.89	-1.28	0.22

Radiography Programme 2003&2004 YR1-2	Paired-sample	Mean scores		t-statistic	Significance
	Size	Interim Yr 2	Post-test Yr 2		*p-value*
Deep Approach	**18**	**32.11**	**31.22**	**-1.15**	**0.27**
Deep Motive	18	15.89	15.50	-0.81	0.43
Deep Strategy	18	16.22	15.72	-1.21	0.24
Surface Approach	**18**	**28.39**	**28.83**	**0.39**	**0.70**
Surface Motive	18	13.50	13.56	0.80	0.94
Surface Strategy	18	14.89	15.28	0.63	0.54

Radiography Programme 2003&2004 YR1-2	Paired-sample	Mean scores (Overall Differences)		t-statistic	Significance
	Size	Pre-test Yr 1	Post-test Yr 2		*p-value*
Deep Approach	**18**	**30.06**	**31.22**	**0.78**	**0.44**
Deep Motive	18	14.61	15.50	1.02	0.32
Deep Strategy	18	15.44	15.72	0.39	0.71
Surface Approach	**18**	**25.50**	**28.83**	**2.41****	**0.03**
Surface Motive	18	11.83	13.56	1.90*	0.08
Surface Strategy	18	13.67	15.28	2.31**	0.03

The null hypothesis and alternative hypothesis are:
H_0: Pre-test score = Post-test score;
H_1: Pre-test score ≠ Post-test score (two-tail test).

Asterisk(s): *, **, & *** denote statistical significance at the 10%, 5%, & 1% levels respectively.

As illustrated, all ‘surface’ scores increased during the 2-year span, and all changes are statistically significant, even though their changes within different intervals were sometimes subtle. Findings are comparable with similar investigations conducted in other sub-projects and consistent with the info revealed in the graphs above.

As for the ‘deep’ scores, the most obvious and statistically significant increases have been recorded during the intervals between Y1 post-test – Y2 pre-test and Y2 pre-test – Y2 interim test. Intuitively, findings are consistent with the history of the programme; there was some instability in terms of the personnel of the programme in the end of this group of students’ year 1 study.

Individual changes (YR1 in the 2004-2005 academic year)

As narrated in the programme restructuring section, the 2004-2005 academic year marked the 2nd year in which the present CA intervention has been under full swing. There are two experimental groups: one group, the year 2 students, has been discussed previously; another group, the year 1 students and their approaches to studying, is discussed as follows.

To recap the illustration of the overall participation number reported above, 30 students have participated in SPQ conducted at the beginning of the 2004-2005 academic year, i.e., pre-test; 23 students have participated in SPQ conducted in the middle of the 2004-2005 academic year, i.e., interim test; 29 students have participated in SPQ conducted at the end of the 2004-2005 academic year, i.e., post-test. Similar to previous procedures, students who did not participate in all three tests are omitted from the analysis. As such, a paired-sample of 22 students has resulted. They are denoted 'Radiography programme 2004 YR1'.

Paired-sample standard t-tests were carried out to examine the difference in scores between the intervals on the two factors and four sub-factors measured by the questionnaire. Results, hypotheses and statistical significance for this group of students, during their course of study in Year 1 in the 2004-2005 academic year are reported as follows.

Radiography Programme 2004 YR1	**Paired-sample size**	**Mean scores**		**Significance**	
		Pre-test	Interim	*t-stat*	*p-value*
Deep Approach	**22**	**30.82**	**31.86**	**1.02**	**0.32**
Deep Motive	22	15.23	15.95	1.24	0.23
Deep Strategy	22	15.59	15.91	0.45	0.66
Surface Approach	**22**	**25.14**	**25.55**	**0.44**	**0.66**
Surface Motive	22	11.09	11.95	1.54	0.14
Surface Strategy	22	14.05	13.59	-0.80	0.43

Radiography Programme YR1 2004	**Paired-sample size**	**Mean scores**		**Significance**	
		Interim	Post-test	*t-stat*	*p-value*
Deep Approach	**22**	**31.86**	**29.27**	**-2.53****	**0.02**
Deep Motive	22	15.95	14.14	-3.02***	0.01
Deep Strategy	22	15.91	15.14	-1.24	0.23
Surface Approach	**22**	**25.55**	**29.73**	**4.65*****	**0.00**
Surface Motive	22	11.95	14.36	4.16***	0.00
Surface Strategy	22	13.59	15.36	3.13***	0.01

Radiography Programme YR1 2004	**Paired-sample size**	**Mean scores**		**Significance**	
		Pre-test	Post-test	*t-stat*	*p-value*
Deep Approach	**22**	**30.82**	**29.27**	**-1.48**	**0.15**
Deep Motive	22	15.23	14.14	-1.92*	0.07
Deep Strategy	22	15.59	15.14	-0.67	0.51
Surface Approach	**22**	**25.14**	**29.73**	**4.83*****	**0.00**
Surface Motive	22	11.09	14.36	5.49***	0.00
Surface Strategy	22	14.05	15.36	2.34**	0.03

The null hypothesis and alternative hypothesis are:
H_0: Pre-test score = Post-test score;
H_1: Pre-test score ≠ Post-test score (two-tail test).

Asterisk(s): *, **, & *** denote statistical significance at the 10%, 5%, & 1% levels respectively.

Discussions

Overall, all 'deep' scores have decreased and all 'surface' scores have increased between pre-test and post-test. The differences are especially significant during the interval between interim test and post-test (all differences are statistically significant except one, i.e., deep strategy). Nevertheless, the differences between pre-test and interim test are subtle, without a clear trend, and statistically insignificant.

Comparisons with control groups

Similar to previous analyses, we like to contrast the differences, if any, in approaches to studying between this captioned experimental group and control groups. As for the data collected in the 2004-2005 academic year, both the year 1 students and the year 2 students are experimental groups. Both groups participated in the pre-test, interim test, and post-test at the beginning, in the middle, and at the end of the 2004-2005 academic year respectively. However, at the time of the pre-test, the year 2 students have experienced one full year of the constructive alignment intervention already. The year 1 students, in the meantime, haven't experienced such intervention at the time of the pre-test, a condition which is similar to the three control groups adopted previously for our analysis of data collected in the 2003-2004 academic year. This experimental group, denoted 'Radiography programme 2004 YR1' constitute an experimental group. Their differences in approaches to studying recorded during the pre-test and the interim test interval are computed: *Differences'* = *'interim test score – pre-test score'*. Such differences are compared against those for the control groups employed in our previous analysis. To reiterate, these control groups are denoted 'Control' and 'Control OR Only'. Results, hypotheses and statistical significance are reported as follows.

Radiography programme 2004 YR1 vs. Control

Radiography programme 2004 YR1 vs. Control	**Sample size**	**Mean difference**		**t-statistic**	**Significance**
	2004 YR1/Control	2004 YR1	Control		*p value*
Deep Approach Difference	**22/164**	**1.05**	**-0.18**	**1.19**	**0.23**
Deep Motive Difference	22/164	0.73	0.20	0.89	0.38
Deep Strategy Difference	22/164	0.32	-0.37	1.10	0.69
Surface Approach Difference	**22/164**	**0.41**	**3.34**	**-2.67*******	**0.01**
Surface Motive Difference	22/164	0.86	2.04	-1.75*	0.08
Surface Strategy Difference	22/164	-0.45	1.30	-2.82***	0.01

The null hypothesis and alternative hypothesis are:

H_0: Radiography programme 2004 YR1 pre-test & interim test difference = Control pre-test & post-test difference;

H_1: Radiography programme 2004 YR1 pre-test & interim test difference ≠ Control pre-test & post-test difference (two-tail test).

Asterisk(s): *, **, & *** denote statistical significance at the 10%, 5%, & 1% levels respectively.

Radiography programme 2004 YR1 vs. Control OR Only

Radiography programme 2004 YR1 vs. Control OR Only	**Sample size**	**Mean difference**		**t-statistic**	**Significance**
	2004 YR1/Control	2004 YR1	Control OR Only		*p value*
Deep Approach Difference	**22/31**	**1.05**	**-0.84**	**1.62**	**0.11**
Deep Motive Difference	22/31	0.73	-0.44	1.67	0.10
Deep Strategy Difference	22/31	0.32	-0.41	0.92	0.36
Surface Approach Difference	**22/31**	**0.41**	**2.16**	**-1.67**	**0.10**
Surface Motive Difference	22/31	0.86	1.56	-1.09	0.28
Surface Strategy Difference	22/31	-0.45	0.59	-1.56	0.13

The null hypothesis and alternative hypothesis are:

H_0: Radiography programme 2004 YR1 pre-test & interim test difference = Control OR Only pre-test & post-test difference;

H_1: Radiography programme 2004 YR1 pre-test & interim test difference ≠ Control OR Only pre-test & post-test difference (two-tail test).

When the comparison is with the entire control group, those differences in 'deep' scores for the experimental group consistently are superior to those of the control group. Meanwhile, those differences in 'surface' scores for the experimental group consistently are inferior to those of the control group. All differences in surface scores are statistically significant but all differences in 'deep' scores are statistically insignificant.

When the comparison is with the control group containing OR students only, those differences in 'deep' scores for the experimental group consistently are superior to those of the control group. Meanwhile, those differences in 'surface' scores for the experimental group consistently are inferior to those of the control group. All differences, however, are statistically insignificant.

Results have indicated that the experimental group is more likely to pursue understanding than the control groups and less likely to engage in rote learning than the control groups since the beginning of the CA intervention. Results are quite encouraging indeed.

One final note: as for the changes in the deep approach and surface approach scores at several points (e.g., beginning, middle, and the end or pre-test and post-test) over the period of implementation (e.g., one semester), most other studies under this current main project, as per other sub-project web-based reports, and other control group samples illustrated similar patterns, i.e., deep approach scores would drop over the period of implementation and surface approach scores would rise over the period of implementation. Some sub-projects found the rise of the surface approach scores were statistically less significant than that of the control groups, whilst some sub-projects found the drop of the deep approach scores were statistically less significant than that of the control groups. To sum up, results reported earlier were not surprising. They were quite reasonable and from time to time encouraging indeed.

Closing Remarks

Constructive Alignment is the guiding principle in overhauling the curriculum of a radiography programme. By restructuring the content and integrating different streams, the programme matches the technological progression and the demand form the society. There are positive impacts on students. In addition, there are positive effects on the teaching staff too.

Even though the current programme has been existing for years, all teachers within the programme did not talk to the others much in the past. The lack of communication not only was observed between teachers teaching different subjects, but between teachers teaching the same subjects in different years too. That was very much unhealthy from the programme perspective, as the content of the education our students received would be incohesive, incoherent, and overlapping. Beside, there were too many class hours in the past devoted to didactic lectures in which students plainly copied some notes on the projector. Interaction between students and faculty was minimal and, as such, there were no interim feedback from the students during the course of their study. Such problems arisen partially due to the lack of communication between teaching staff and that the programme itself was not constructively aligned.

Driven mainly in response to the technological progression and financial constraints, this constructive alignment intervention not only has revitalised our programme, it has enhanced the relationship and the cohesiveness of our faculty too. The implementation of this constructive alignment exercise also has given several faculty members opportunities to investigate what the industry dynamics have been going on and what kind of skills and knowledge are expected to be possessed by our graduates. In the course of the investigation and this constructive alignment exercise, the programme leader is pleased to write appropriate and desirable outcomes for the contemporary and effectively integrated curriculum.

In many ways, to see the programme heading towards the right direction, students having fruitful interaction between themselves and with the teaching staff and receiving a useful education definitely worth the tedious hours and the tiredness endured during these years. We are certain that constructive alignment is guiding our programme towards the right direction, and more success and impacts are coming.