

# HEALTH AND SAFETY IN CIVIL ENGINEERING EDUCATION: A CASE STUDY

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## ABSTRACT

The high rate of fatal and serious accidents in construction workplaces is annually reported. The recognized lack of health and safety, risk prevention and risk management content in undergraduate and postgraduate curricula of civil engineering, revealed some years ago the necessity of a specific regulation of construction sector. The introduction of these specific issues in the civil engineering curricula implied a study about civil engineering students' health and safety education and risk management attitudes. This paper demonstrated the method that has been used to introduce occupational risk prevention integrated in the construction process, in construction management units and in specific units. Surveys were applied to the students to evaluate their level of construction risk management training and its results are reported in this paper.

**Keywords:** Health and safety, Risk management, Civil engineering, Education and training.

## INTRODUCTION

Occupational health and safety has long deserved great attention by the European Union and has been the object of a legal framework, extended to all activity sectors (Directive 89/391/EEC). In particular, the construction industry has deserved the special concern of the European Nations because of its specific nature and high contribution to fatal labour accidents. This led the European Council to release the Temporary or Mobile Construction Sites Directive (Directive 92/57/EEC). Both Directives are presently incorporated in the internal law of all European countries in the form of legal regulations, concerning health and safety conditions of workers during construction and subsequent operations.

Health and safety regulations take into account the specific nature of the construction industry and follow a general health and safety approach in construction sites, considering all phases of project development and enforcing liability of all project participants. The approach followed in the regulations is centred on the concept of health and safety coordination that must be assured by two coordinators, acting during the project preparation stage and project execution stage. However, these regulations establish a liability chain for health and safety, involving all other project participants in addition to coordinators and requiring their deep involvement in the task of eliminating/preventing health and safety risks for workers during the execution stage and in the course of subsequent construction and maintenance work. Therefore, according to regulations, all project participants should have enough knowledge of health and safety matters to perform their duties (Rodrigues, 1999).

The Temporary or Mobile Construction Sites Directive (Directive 92/57/EEC) created great challenges in health and safety risk management education and training, because it established new functions in occupational hazards prevention for all the participants in the construction sector and demanded the intervention of health and safety coordinators, from the initial project preparation stage (Rodrigues and Maranhão, 2007).

This Directive indicates occupational hazard prevention from before the execution phase. So, the existence of a competent health and safety coordinator from the beginning of the design phase is an important factor that contributes to reaching high safety levels on construction sites. The

Directive's contents will only be applied efficiently, with full achievement of its objectives, if specific education and training be provided to construction technicians. In this way they are able to achieve the skills and knowledge that enable them to implement the functions that are required by health and safety coordinators such as: coordinating the activities of all the participants during the design and the execution phase with the aim of integrating health and safety prevention principles. From the early design phase this will influence the execution of the construction schedule, the quality of the work, the construction, use, maintenance, repair, rehabilitation and demolition performance of the construction projects (Rodrigues and Maranhão, 2007).

Civil engineering has long been the most recognised technical degree for working in any construction area in Portugal. The previous civil engineering education in Portugal offered a broad five-year undergraduate programme, covering a variety of areas such as structures, foundations, hydraulics, construction materials, construction technology, roads and town planning. Accordingly, a considerable part of project design (including structural, foundation and most installation design), as well as project management, quantity surveying and quality management duties, is currently carried out by civil engineers in Portugal. All of the above duties must be conducted in accordance with health and safety regulations, therefore imposing specific training in this area on civil engineers. Otherwise, safety issues may be considered either through specific courses or included in current course syllabi (Rodrigues and Teixeira, 2003).

The problem is how to provide health and safety knowledge to construction professionals. Obviously, health and safety coordination should be the object of specific training designed for a variety of professionals with different backgrounds. Specific training must also be envisaged for people performing other functions in the construction activity, namely civil engineers. This could possibly be achieved in two ways or in a combination of both: either considering specific courses or including relevant topics on various subjects in current courses (Rodrigues and Maranhão, 2007).

A consequence of research on the construction health and safety coordinators' education and training, developed during the preparation of one of the author's Masters thesis (Rodrigues, 1999), was to improve the knowledge of construction health and safety of the Civil Engineering students of Aveiro University. An optional course on Construction Health and Safety was firstly implemented in 2003/04, and fundamental concepts of health and safety coordination have been introduced in the Construction Management syllabus since 2001/02. Positive impacts of this action have been registered as students use knowledge acquired on this topic in their final project work.

The transformation of the former system, which leads after five years of study to the academic degree of civil engineer, into the academic undergraduate course and the Master of Civil Engineering in accordance with the Bologna agenda, has been studied carefully, and new courses introduced. The aim of this paper is to show the methods that have been used to integrate health and safety risk prevention in the construction process, in construction management lessons and in specific courses, and the evolution of the students' knowledge and attitudes towards construction health and safety risks management.

## **THE CONSTRUCTION HEALTH AND SAFETY COORDINATORS' EDUCATION AND TRAINING**

The lack of health and safety risk prevention and risk management knowledge of the construction technical intervenient are frequently the cause of severe and fatal injuries in this industry. This lack of knowledge and the poor attitude towards health and safety risk management lead the participants to fail to implement correct planning of risk prevention measures, throughout the entire construction act (design, execution and use phase of the constructed element). Neither do they evaluate the consequences of their decisions on safety. Over the years the recognised insufficient safety qualifications of construction technicians led to the exigency of health and safety coordinators created by the previously mentioned European Directive (Rodrigues, 1999).

The influence of the Regulations (Construction Design and Management Regulations – CDM Regulations) that had consequently come into force in the United Kingdom, were investigated and

it was concluded that the regulations had failed to achieve the intended outcome. The responsibility was associated with design professionals for failing to make them work, this being the main influence on construction site safety temporary works design. Thus this is a problem of the safety attitude and/or awareness of the designers. In addition, during the execution phase companies have demonstrated a negative attitude towards health and safety risk management (Petersen et al., 2008). The same problems seem to occur in all European countries and these conclusions can also be transported to Portugal as the problems are similar.

The required fundamental modification of safety procedures depends on the qualifications of all the participants during the entire construction act. Only well prepared coordinators can achieve the most correct safety solutions and obtain from the entire design and execution team their understanding and implementation. These qualifications are only obtained through their academic background, their safety specific education or professional training and through professional experience.

Specific health and safety coordination training courses have been developed in Portugal. The first initiative took place in 1999 at the Technical University of Lisbon, and several editions have been conducted since. In 2002, the Portuguese Board of Engineers organised another initiative on the same topic and conducted several editions, followed by the Portuguese Board of Architects, Universities and particular training institutions. The University of Aveiro followed and ran its first specific training course in 2003 and has now conducted 7 editions. The courses consist of 120 hours of tuition and 80 hours of practical work and complies with the syllabus published by the Portuguese Health and Safety Authority (Working Conditions Authority – ACT).

## **HEALTH AND SAFETY CIVIL ENGINEERING EDUCATION**

The Bologna declaration has triggered an important change in Europe in the organisation of academic engineering education (Biesen et al., 2009). In Portugal, as in many other European countries, engineering education had to be completely reconsidered and revised.

The previous engineering education system in Portugal was based on five years of study for the academic degree of civil engineer.

The transformation of the former system into a three year academic undergraduate course and two year Master of Civil Engineering in accordance with Bologna requirements altered the existing programme. The new programmes should be consistent with the European Credit Transfer and Accumulation System - ECTS, where an average of 30 ECTS per semester should be scheduled, yielding 60 ECTS per study year, or 180 ECTS for the undergraduate Civil Engineering degree and 120 for the Master degree. The new programmes must fulfil these requirements as well as technical ones, and should match the aspirations in the field, i.e., the labour market and the construction industry. Accordingly, at the University of Aveiro, the Civil Engineering curriculum was adapted, and the former Construction Management syllabus modified and three new courses were created during the two years of the Master: the compulsory unit of “Construction Management and Safety Coordination” and two other optional courses “Construction Risk Prevention” and “Construction Design and Execution Safety Coordination” (Table 1).

Table 1: New courses characterisation

<b>Course</b>	<b>Characteristics</b>	<b>Summarised syllabus</b>
Construction Management	Compulsory unit Master 1 <sup>st</sup> year 1 <sup>st</sup> semester Syllabus modification in the academic year of 2008-2009	Legal requirements applied to the construction sector. The construction design and execution intervenient's functions and responsibilities. Planning and preparing a worksite. Making the project bill. Studying and designing the working site of a construction including safety measures. To know the general safety rules on construction site management including working equipment.
Construction Management and Safety Coordination	Compulsory unit Master 1 <sup>st</sup> year 2 <sup>nd</sup> semester Beginning in the academic year of 2007-2008	Project planning. Planning software tools. Health and safety at construction worksites. Health and safety management system in construction. Environmental management system in construction. Quality management system in construction.
Construction Risk Prevention	Optional unit Master 2 <sup>nd</sup> year 1 <sup>st</sup> semester Beginning in the academic year of 2008-2009	Legal requirements on health and safety. Risk assessment and risk management. Constructive procedures analysis. Safety measures applied to constructive methods.
Construction Design and Execution Safety Coordination	Optional unit Master 2 <sup>nd</sup> year 2 <sup>nd</sup> semester Beginning in the academic year of 2008-2009	The health and safety coordination system implementation. Coordinators' functions and responsibilities. The construction design and execution intervenient's health and safety functions and responsibilities The drawing up of the: Prior Notice, Health and Safety Plan, Health and Safety File, accordingly to the Temporary or Mobile Construction Sites Directive (Directive 92/57/EEC).

In this way all the students during their Master first year (formerly equivalent to the fourth undergraduate Civil Engineering year) can gain general knowledge and a correct attitude towards health and safety issues. During this year, through the Construction Management and the Construction Management and Safety Coordination units' syllabi, the students gain knowledge about safety legal requirements, construction design and execution health and safety coordination, health and safety measures design and execution implementation. The students that attend the two specific options will be more thoroughly prepared to carry out risk assessment and risk management in construction work, to implement the construction health and safety coordination system and to draw up the health and safety instruments: the prior notice, the health and safety plan, and the health and safety file.

The Construction Management course was always part of the Civil Engineering curricula in the University of Aveiro and the lecturers have always considered general health and safety issues. The Construction Management and Safety Coordination units were introduced in the 2007-2008 academic year and the two options only during the 2008-2009 academic year. During the lessons of the two compulsory units and the Construction Risk Prevention unit, the lecturer explains the subject matter and the students are required to develop applied practical work related to this. The Construction Risk Prevention lessons also require specific research work including class oral presentation by the students.

In the Construction Design and Execution Safety Coordination unit the teaching method is similar but the lecturer complements the lessons with seminars conducted by invited specialists that are

working in construction project design teams or on construction sites. These specialists are chosen because of their deep knowledge and experience in construction design and safety coordination as well as in construction technologies and processes, construction design and execution management. For one week the students also attend a practical construction site placement, being integrated in the health and safety execution coordination team.

In all four of these units the students are evaluated on their practical and research work and on a written final evaluation. In addition the Construction Design and Execution Safety Coordination evaluation is complemented with a public presentation of the unit's final piece of work. The evaluation of the completed work and its presentation is done by the lecturer and by an external specialist chosen from the several that have conducted the aforementioned seminars.

## **SURVEY DEVELOPMENT AND ADMINISTRATION**

The surveys carried out for this study were developed by the authors, lecturers in the Civil Engineering Department of the University of Aveiro, and were administered during the second semester of the 2008-2009 academic year. The target population for this study was the third year undergraduate students and the first and second year Master students of the Civil Engineering Department, University of Aveiro, who were registered in the second semester for:

- two compulsory units (one in the third undergraduate year and the other in the Master first year: Construction Management and Safety Coordination);
- one optional unit, Construction Design and Execution Safety Coordination.

The compulsory unit in the third undergraduate year had 49 students enrolled and the one in the first year of the Master 68 students enrolled. The optional unit where the survey was also administered consisted of 15 registered students.

The focus of the survey that was directed to the students of the third graduate year (at the beginning of the semester) was to evaluate their attitude and knowledge of health and safety risk management before they attended course units where these matters are studied (the two compulsory units in their next year). The survey that was administered regarding the compulsory unit in the first year of the Master and the optional unit in the second year of the Master (at the beginning of the semester) aimed to evaluate their attitude and knowledge of health and safety risk management after they have attended one or two units whose syllabi contain health and safety matters. The questionnaire that was directed to these two units at the end of the semester aimed to determine the changes and evolution of their attitude and knowledge of health and safety risk management after educating them.

The following five-point Likert scale was developed for each question in both surveys: 1 = very poor; 2 = poor; 3 = normal (average); 4 = good; 5 = very good. The surveys were set as part of the coursework for all three units to ensure that they were completed by the students. The surveys were also administered on the internet.

A total of 29 third-year undergraduate civil engineering students completed their survey in the correct format and at the requested time. The percentage of these respondents corresponds to 16.6% of the registered student population of the third undergraduate year (175 students). A total of 59 students of the Construction Management and Safety Coordination unit and of the Construction Design and Execution Safety Coordination unit completed their survey in the correct format and at the requested time. Of these 25.4% were registered on the third-year undergraduate-programme, 32.2% on the first-year Master and 42.4% on the second-year Master. The percentage of these respondents corresponds to 80.8% of the target student population for these two units and to 73.8% of the registered students in the first and second years of the Master. The lower response rate of 16.6% from the third-year undergraduate students is explained as the survey was administered only during the classes of one unit that had 49 students enrolled. This number was considered representative of this year, because the expected answers of the rest of the students would be similar to those obtained.

With the recent transition to the Bologna format some students are studying units from the undergraduate years simultaneously with Master units. As the lecturer of the four units referred to in Table 1, one of the authors, had not lectured during the previous three academic years (from the beginning of the second semester of 2005 until the beginning of the second semester of 2008), the students that attended the Construction Management course did not study the current syllabus with a greater emphasis on construction site risk prevention. Of the other three units, one began in the 2007-2008 academic year, and the other two in the 2008-2009 academic year, as previously mentioned.

The results from the analysis of the administered surveys are described in the next section.

## RESULTS AND DISCUSSION

During the surveys at the beginning of the 2008-2009 second academic semester, the students were asked if they had knowledge about occupational health and safety, health and safety legal requirements and construction risk prevention. Table 2 illustrates the knowledge of health and safety attitudes of the third-year undergraduate and Construction Management and Safety Coordination and Construction Design and Execution Safety Coordination students surveyed.

The third year undergraduate students that answered positively to the questions, mentioned that they had acquired general health and safety knowledge through the media (87.5%), and three of them (6.8%) had just attended the Construction Management and Construction Management and Safety Coordination units during the previous year (they are students due to take this third-undergraduate unit later on). The positive answer about the knowledge of health and safety regulations is in accordance with the positive answer to the first question. The third question's positive answers are unexpected because the percentage is higher than the 6.8% of students that have attended Construction Management classes. This may be explained by the students interpreting their limited experience of working within a safety conscious culture.

From the 64.4% of students of the other group (on the other two courses surveyed) that answered positively to the first question, 47.4% indicated that they had obtained that knowledge through the media (general culture), on attendance of: Construction Management 21.1%; Construction Management and Construction Risk Prevention 15.8%; Construction Management and Construction Management and Safety Coordination 2.6%; Construction Management, Construction Risk Prevention and Construction Management and Safety Coordination 7.9%. There is one respondent who had gained this knowledge from industry experience and another from the previously referred to optional course on Construction Health and Safety they had attended at the University (whose lecturer was one of the authors). All the positive answers to the second and third questions are from the students that have attended the courses: Construction Management, Construction Management and Safety Coordination and Construction Risk Prevention.

Table 2 – Self evaluation of students' occupational health and safety knowledge

Questions	Occupational H&S		H&S Legal requirements		Construction risks prevention	
	Yes	No	Yes	No	Yes	No
Third-year undergraduate unit	55.2	44.8	6.9	93.1	10.3	89.7
Construction Management and Safety Coordination unit, Construction Design and Execution Safety Coordination unit	64.4	35.6	30.5	69.5	23.7	76.3

The two groups of students were asked to rate their attitude and knowledge of health and safety risk management and related legal requirements using the five point scale. Table 3 illustrates the third-year undergraduate students' self-rating and Table 4 depicts the results of the students' self-rating of the two units surveyed: Construction Management and Safety Coordination and Construction Design and Execution Safety Coordination.

The results in Table 3 indicate that 65.5% of these students rated their attitudes towards construction health and safety prevention as poor or very poor, and about 76% maintained their knowledge of health and safety legal regulations and risk management on construction to be equally limited. The rest of the students rated their attitudes and knowledge as average. Additionally, the results of the other group of students (Table 4) depict a higher percentage of their self-rated attitudes towards health and safety risk management as good. These statistics indicate that there was a positive change in the attitude of these students towards health and safety risk management, after being educated in one or more than one of the Construction Management, Construction Management and Safety Coordination, Construction Risk Prevention units.

Table 3 – Third-year undergraduate self-rating of the student's attitude towards and knowledge of construction health and safety risk management

Questions	Very poor (%)	Poor (%)	Average (%)	Good (%)	Very good (%)
How do you rate your attitude towards construction health and safety risk prevention?	3.4	62.1	34.5	0	0
How do you rate your knowledge of health and safety legal regulations?	27.6	48.3	24.1	0	0
How do you rate your knowledge of construction health and safety risk management?	20.7	55.2	24.1	0	0

Table 4 – Self-rating of the students' attitude towards and knowledge of construction health and safety risk management of Construction Management and Safety Coordination, Construction Design and Execution Safety Coordination units

Questions	Very poor (%)	Poor (%)	Average (%)	Good (%)	Very good (%)
How do you rate your attitude towards construction health and safety risk prevention?	3.4	40.7	32.2	23.7	0
How do you rate your knowledge of health and safety legal regulations?	5.1	66.1	23.7	3.4	0
How do you rate your knowledge of construction health and safety risk management?	5.1	57.6	23.7	13.6	0

At the end of the 2008-2009 second semester the same enquiry was administrated to the second group of students. The questionnaire had only one new question: how do you rate the evolution of your attitude towards construction health and safety risk management?

The survey was presented separately to the students of the optional unit (Construction Design and Execution Safety Coordination) and to the students of the compulsory unit (Construction Management and Safety Coordination) to evaluate their different evolution, because the optional unit has a more specific and thorough syllabus on construction risk management and health and safety construction coordination.

Of the optional unit's students, 46.7% have attended the four courses, or the two compulsory units and the optional one, and only one student (2.6%) has attended one of the compulsory units and the optional one. 100% of the students responded positively to the questions about whether they have knowledge of occupational health and safety, health and safety legal requirements and construction risks prevention. The results in Table 5 indicate that 73.3% of these students rated their attitudes towards construction health and safety prevention and their knowledge of health and safety legal regulations as good or very good, and 86.7% rated their knowledge regarding construction risk management on construction as good or very good.

The positive evolution that they have achieved in their knowledge and attitude towards risk management on construction industry during the design phase, execution and use phase is clear. All the students self-rated the evolution of their attitude towards construction health and safety risk management as good (46.7%) or very good (53.3%). All these students have classified the lectures as good (46.7%) and very good (53.3%). The conferences given by invited external professionals, specialists in the construction industry, were rated as good (33.3%) and very good (66.7%). The interest of the practical work they were asked to develop during the lessons was rated as good and very good (46.7%) and as average (6.7%), taking up 25% to 50% of their time dedicated to this unit.

Regarding the compulsory unit at the end of the semester, 100% of the students answered that they have knowledge of occupational health and safety and health and safety legal requirements. Regarding construction risk prevention knowledge, only two (7.1%) answered negatively in spite of having mentioned that they have average or good preparation in the subjects enquired about in the first 3 questions of Table 6. It seems that these students have not clearly understood the questionnaire. All the target students indicated that they have acquired this knowledge through the compulsory unit of Construction Management and Safety Coordination. However, only 25% of the students indicated that they also achieved this from the Construction Management compulsory unit, despite all of them having attended these lessons. This low rate is explainable because the second semester compulsory unit is more recent in their study memory.

Table 5 – Self-rating of the students' attitude towards and knowledge of construction health and safety risk management from the Construction Design and Execution Safety Coordination unit

Questions	Very poor (%)	Poor (%)	Average (%)	Good (%)	Very good (%)
How do you rate your attitude towards construction health and safety risk prevention?	0	0	26.7	60.0	13.3
How do you rate your knowledge of health and safety legal regulations?	0	0	26.7	73.3	0
How do you rate your knowledge of construction health and safety risk management?	0	0	13.3	80.0	6.7
How do you rate the evolution of your attitude towards construction health and safety risk management?	0	0	0.0	46.7	53.5

The results in Table 6 indicate that 88.1% of the students rated their attitudes towards construction health and safety prevention as average and good. There are 7.1% who rated their attitudes as poor and 4.8% as very good. These very good results can be justified by unreal perception of their own knowledge. 97.6% of students self-rated their knowledge towards health and safety legal regulations as average (69.0%) and good (28.6%), and 92.8% rated their knowledge of construction risk management on construction as average (57.2%) and good (35.7%).



It is clear that they have achieved a positive evolution in their knowledge and attitude towards risk management in the construction industry since the beginning of the second 2008-2009 semester, comparing the results of Table 6 with Table 4. The students self-rated the evolution of their attitude towards construction health and safety risk management, without any negative responses, as average (28.6%), good (52.4%) and very good (19.0%).

The vast majority of the respondents have classified the lectures as average (19.1%) good (71.4%) and very good (7.1%). Only one student (2.4%) has classified them as poor. The interest level of the practical work they were asked to develop during the lessons was rated as good and very good (78.5%) and as average (19.1%), consuming from 20% to 80% of their time dedicated to this unit. Only one student (2.4%) classified this work as being of little interest.

Table 6 – Self-rating of the students' attitude towards and knowledge of construction health and safety risk management from the Construction Management and Safety Coordination unit

Questions	Very poor (%)	Poor (%)	Average (%)	Good (%)	Very good (%)
How do you rate your attitude towards construction health and safety risk prevention?	0	7.1	50.0	38.1	4.8
How do you rate your knowledge's of health and safety regulations?	0	2.4	69.0	28.6	0
How do you rate your knowledge of construction health and safety risk management?	0	7.1	57.2	35.7	0
How do you rate the evolution of your attitude towards construction health and safety risk management?	0	0	28.6	52.4	19.0

Comparing Table 5 with Table 6's results, it can be concluded that the students evaluated in Table 5 revealed deeper knowledge than the students rated in Table 6. In fact the majority of these students have attended the two compulsory units and one or two optional ones that permitted them to achieve more knowledge of specific and deeper health and safety risk management.

## LECTURES' EVALUATION

The evaluation of the students work (practical work and individual written evaluation) throughout the semesters indicates that the students that only attended the two compulsory units achieved a better understanding of the health and safety issues and obligations, and of a range of safety measures that must be implemented on construction sites. These students are conscious of these matters and can by themselves or through professional training gain deeper knowledge of health and safety risk prevention. Accordingly they are not prepared to conduct a construction health and safety coordination system without attending specific professional training.

On the other hand the 15 students of the optional unit, Construction Design and Execution Safety Coordination, effectively revealed deeper knowledge of risk management and are prepared to be integrated in health and safety coordination teams. Their individual evaluation has revealed that on a scale from 0 to 20: 20.0% have a very good rating (17 values), 46.7% a good evaluation (from 14 to 15 values) and 33.3% a satisfactory evaluation (from 11 to 13 values). These evaluations demonstrated that they have effectively gained a major and positive evolution in their knowledge of risk prevention, risk management and specifically in construction health and safety coordination. In spite of this, it is essential that they gain experience integrated in specialised construction design and execution teams.

## CONCLUSIONS

The health and safety risk management record in the construction industry is still poor due to poor attitudes of construction professionals and their lack of knowledge of health and safety risk management. Although the rate of accidents has decreased over the last few years, the rate of accidents in the construction industry is still higher than all other industries in Portugal (ACT, 2009).

The Civil Engineering Department of the University of Aveiro has created a range of four units with general and specific subjects focusing on occupational health and safety, construction health and safety risk management, design and site construction health and safety coordination.

Through the results of the survey presented, it can be concluded that the methods and syllabus implemented embed a positive health and safety risk management culture within the student body. The attitudes of students towards health and safety risk management improved during their attendance of these units. The majority of the students that have only attended the two compulsory units claimed to have an average attitude towards health and safety risk management. On the other hand the majority of students that have also attended one or two of the optional units claimed to have a good or very good attitude towards these matters. Similarly the students perceived that their knowledge of health and safety risk management had improved: 100% of the optional unit surveyed claimed to have a good or very good understanding of health and safety risk management against 71.4% of the compulsory unit students. The students that have undertaken the four units are also prepared to exercise construction health and safety coordination in spite of their education needing to be complemented with in site and design experience.

This assessment method will be continuing in the following academic year to permit consideration of the continuing evolution of the results.

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