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Assessing the relevance of higher education courses

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Abstract

The establishment of the European Higher Education Area has involved specifying lists of professional competencies that programs are expected to develop, and with this the need for procedures to measure how every course within a higher education program is aligned with the program's competencies. We propose an instrument for characterizing this alignment, a process that we call assessing the relevance of a course. Using information from the course syllabus (objectives, contents and assessment scheme), our instrument produces indicators for characterizing the syllabus in terms of a competence list and for assessing its coherence. Because assessment involves quality, the results obtained can also be used to revise and improve the course syllabus. We illustrate this process with an example of a methods course from a mathematics teacher education program at a Spanish university.
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1. Introduction

There is currently a move toward standards in higher education (Jackson, 1998; Randall, 2002). This move emphasizes a requirement for accountability (Wiley, 2005) and a corresponding quality assurance effort (El–Khawas, DePietro–Jurand, & Holm–Nielsen, 1998; Segers & Dochy, 1996). In the United States, for example, the International Board of Standards for Training, Performance and Instruction (ibstpi) has developed competencies for professional practitioners in a wide range of areas (Klein & Richey, 2005; Spector et al., 2006). In Europe, the implementation of the European Higher Education Area involves establishing a set of competencies (both generic and specific) for each professional profile, including that of teachers (González & Wagenaar, 2003a). The quality assurance of programs is expected to include "careful attention to curriculum and programme design and content" (ENQA, 2005, p. 16).

In this context, instructional design oriented to the development of competencies has become an institutional concern in higher education, and research in this area has developed models adapted to this paradigm (Fallows & Steven, 2000a; Pimienta & Meléndez, 2005; Voorhees, 2001). However, different alignment problems arise (Cowan, George, & Pinheiro-Torres, 2004), in particular, the issue of assessing the compliance of the individual courses in a program with the competencies assigned to the program (Toohey, 1999). Given that course design is one of the determining components in the quality assurance perspective (Henderson-Smart, Winning, Gerzina, King, & Hyde, 2006), the results of this assessment are to be used to improve program quality (Biggs, 1999). The focus of this paper is to propose a method for analyzing some aspects of a course syllabus (objectives, contents and assessment) in terms of the competencies to which it is expected to contribute. We call this process assessing the relevance of a course. We describe an instrument to perform this relevance assessment and provide an example of the

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process, taking as a model a mathematics teacher education course.

We start the paper justifying the need for instruments to assess the alignment of a course with a list of competencies and introduce the key notions involved. On the basis of these notions, we introduce the ideas of relevance dimensions and indicators to describe the detailed procedures involved in the relevance assessment instrument we propose. Finally, we put in practice those procedures to assess the relevance of a prospective secondary mathematics teachers' methods course and suggest how the results can be interpreted from the perspective of the syllabus design.

2. Alignment of syllabi with competencies: characterizing relevance

Around the world, teachers are being required to document to what extent their courses support the development of generic skills (Bath, Smith, Stein, & Swann, 2004), and accreditation standards and agencies have been established (ANECA (n.d.); National Council for Accreditation of Teacher Education, 2002; Randall, 2002; Volkwein, Lattuca, Harper, & Domingo, 2007). In Europe, following the Bologna Declaration (Bologna Declaration, 1999), several procedures for quality assurance were established in European higher education institutions (Bornmann, Mittag, & Daniel, 2006; Jeliazkova & Westerheijden, 2002). However, there is still confusion and doubt about how to implement them (Haug, 2003). The Tuning project has identified points of reference for generic and subject-specific competencies of first and second cycle graduates in Europe (González & Wagenaar, 2003a). In this project, quality "was considered as a fundamental element for trust and relevance in terms of employability and citizenship and of preparation of graduates for crucial issues to be able to participate, work and live in a permanently changing society." (González & Wagenaar, 2003b, p. 242). The Tuning project has developed a model for designing, planning and implementing curricula offered within an institution (Deane & Watters, 2004; Fallows & Steven, 2000b). The institution must define academic and professional profiles; describe the objectives of the program as well as the learning outcomes (in terms of knowledge, understanding and skills); identify the generic and subject-related competencies; distribute them into course units or modules; decide the approaches to teaching and learning, as well as the methods of assessment; translate them into educational units and activities; and design a program of quality assurance. In this study, we will assume that the curriculum design of a program structures its courses in such a way that fulfilling the different courses' competencies leads to the achievement of the corresponding program's competencies. In particular, the program design might assign a subset of the program's competencies to each course.

Competencies describe learning outcomes: what a learner knows or is able to demonstrate after the completion of a learning process. The notion of competence involves a combination of attributes—knowledge, capabilities, skills and attitudes—that enable an individual or group to perform a role or set of tasks (Preston & Walker, 1993, p. 118). This idea has been widely reformulated (see, for example, Richey, 2002) and different organisms and projects have described concrete lists of competencies [Tuning (González & Wagenaar, 2003a), DeSeCo (OECD, 2005), ibstpi (Klein & Richey, 2005; Spector et al., 2006), TenCompetence (Kew, 2006)]. Determining whether a course design is aligned with a list of competencies involves a broad variety of meanings, ranging from the correspondence of the course level and the students' previous knowledge to identifying incoherencies or gaps in the course syllabus (Webb, 1997; Glatthorn, 1999). Before checking whether the competencies are developed in practice once the course syllabus is implemented, one should assess from the curriculum design perspective to which extent the syllabus can potentially contribute to the development of these competencies. We will focus on determining the degree to which the course syllabus agrees with the development of a given list of competencies and promotes them coherently. We will refer to this issue as the assessment of the relevance of the course.

We use the course objectives as the lens for establishing the link between the course syllabus and the competencies. The notion of objective reflects the general course outcomes, is used to communicate the teacher's intentions to students and colleagues, and serves as a framework and guide for design of the syllabus as a whole. Courses objectives are considered, in the instructional design processes, as the means of evaluating both the instruction and the learning that has occurred (Gagné, Briggs, & Wager, 1992). Other elements of the syllabus also form part of the process, since determining the coherence of the objectives, content and assessment of the course is also important from the quality perspective (Biggs, 2003).

The relevance of a course is a multidimensional notion. Based on the argument above, we take three dimensions into account. The first two involve the analysis of how and to what extent both the objectives and the syllabus as whole contribute to the development of the competencies. The third dimension explores the coherence with which the syllabus seeks to develop those competencies. Given its multidimensional character, the relevance of a course cannot be captured in a single measure on a given scale. Instead, we consider several measures, the relevance indicators, which are obtained from the different components of the curriculum. Although most of these indicators have a numerical character and are to be measured with ordered scales, they should not be used individually to evaluate specific aspects of the relevance of a syllabus or to compare different syllabi. Their correct interpretation in terms of relevance must be made through the three

dimensions presented above: links between the objectives and the competencies, links between the syllabus and the competencies, and coherence of the syllabus. Given that, when the syllabus is in fact implemented, there is a broad range of factors influencing the development of competences, the contribution to competences we are going to assess with the relevance indicators refers only to the design phase of the course. Our conclusions will, therefore, be oriented to the improvement of components of the syllabus design.

Assessing the relevance of a course can be of interest for different people and institutions. That is the case, for instance, of those responsible of quality assurance in a university or of the person in charge of a teacher education program. In these cases, the instrument can be used for verifying to what extent a given curriculum design aligns with a list of competencies it is supposed to achieve. On the other hand, teacher educators can use the instrument for a different purpose: to check the design of the course in order to improve it.

3. Relevance assessment instrument

3.1. Relevance dimensions and indicators

Three indicators characterize the first relevance dimension, that is, the link between the objectives set up in the syllabus and the list of competencies. The first one, the *zeros on objectives indicator*, identifies those objectives that do not contribute to the development of any competence. The other two, the *objectives' intensity* and *density indicators*, seek to grasp in two different manners, the strength with which each objective is expected to contribute to the development of the competencies it is linked to. On the basis of the information provided by these indicators, it is possible to produce an ordering of the objectives' contribution to the development of the competencies.

We characterize the second relevance dimension, the relationship between the syllabus as whole and the list of competencies, with the help of three additional indicators. The first one, the *zeros on competencies indicator*, identifies those competencies to which the syllabus does not contribute at all. The *intensity of contribution to competencies indicator* seeks to grasp the intensity with which the syllabus contributes to the development of each competence. On the basis of this information, it is possible to produce an ordering of the competencies as a characterization of the syllabus contribution to them. The *time indicator* is a measure of the total time devoted in the syllabus to each competence.

Finally, we introduce two indicators that characterize the third relevance dimension, the coherence of the syllabus from the point of view of its relationship with the list of competencies. For that purpose, we calculate the *competencies assessment weight*, as a measure of the syllabus contribution to each competence in terms of its importance in the assessment scheme of the course. The *correlation indicator* is the correlation between the time indicator and the competencies assessment weight. With the help of this indicator, it is possible to assert whether there is a global incoherence in the manner in which the syllabus design seeks to develop the competencies when the time devoted to them and the importance given to them in the assessment scheme are compared. With the help of regression analysis on the time and assessment variables, we produce the *residual indicator*, with which it is possible to identify the outliers in the competence list. A competence is an outlier when there is incoherence between the time devoted to its development in the syllabus and its importance in the assessment scheme.

In what follows, we suppose that there is a team in charge of assessing the relevance of a course. However, for the sake of simplicity, we will refer to the *assessment person* (AP) as a representative of that team.

3.2. Implementing the relevance assessment instrument

We organize the implementation of the relevance instrument we have just described in three phases (see Table 1). In the first phase, the AP collects the information required for computing the relevance indicators. In the second phase, the relevance indicators are computed in a process that can be automatically carried out, with the help of a spreadsheet. Finally, in the third phase, the information provided by the relevance indicators is used to characterize the alignment of the course syllabus with the

Table 1
Scheme of the relevance assessment instrument

Phase 1	Phase 2	Phase 3
Data collection	Relevance indicators computation	Results interpretation:relevance dimensions
Competencies–objectives matrix	Zeros on objectives	Links objectives-competencies
	Objectives intensity	
	Objectives density	
Time on objectives	Zeros on competencies	Links whole syllabus-competencies
Assessment weight on objectives	Intensity of contribution to competencies	
	Time	
	Correlation residuals	Coherence

competencies through the three dimensions. This characterization can be enhanced with further qualitative information. In what follows, we describe these phases in detail.

3.2.1. Phase 1—Data collection

Given the list of objectives of the course $[O_1,\ldots,O_n]$ and the list of competencies $[C_1,\ldots C_m]$, the AP has to specify which objectives are expected to contribute to which competencies and to which extent. For this purpose, he has to complete the *competencies–objectives matrix* (see Table 2, for a hypothetical case with 5 objectives and 4 competencies). A cell s_{ij} of this matrix represents the strength with which the AP considers that objective O_j contributes to competence C_i. Four ordered cases are possible: 0 = the objective does not contribute to competence, 1 = weak link between the objective and the competence, 2 = considerable and 3 = strong. When the AP chooses a value for a matrix coefficient, he is taking a conceptual decision and he must be able to give reasons for it.

Table 2
Competencies–objectives matrix

Competencies	Objectives				
	O_1	O_2	O_3	O_4	O_5
C_1	0	1	0	0	0
C_2	0	0	3	0	1
C_3	0	2	0	1	1
C_4	0	0	0	0	0

Table 3
Syllabus calendar

Cod.	Content	Content classroom hours
T_1	History of curriculum	2
T_2	Learning theories	4
T_3	Curriculum organizers	4
T_4	Epistemology of mathematics	2
T_5	Problem solving	1
T_6	Didactical unit planning	12
Total		25

Next, the AP has to use the syllabus calendar to estimate the number of classroom hours devoted to the development of each objective. Let us suppose that our hypothetical example is a course of 25 hours distributed as shown in the syllabus calendar given in Table 3. With this information, the AP links each content to their corresponding objectives in order to obtain the values t_j of time devoted to every objective i (see Table 4). In the contents–objectives area of Table 4, the AP puts 1 if he considers that the objective is worked through the corresponding content, and nothing otherwise. Besides, he assumes that the time devoted to every content is equally distributed among all the objectives to which it is linked. For example, content T_6 contributes with $12/4 = 3$ hours to each one of objectives O_1, O_2, O_3, O_4.

There are several possible criteria that the AP can use in order to make these time assignments. The one that we have adopted in the previous computations has been to make a partition of the classroom hours into the objectives. Another criterion could be to consider that there are portions of time simultaneously devoted to the development of several objectives. This is a conceptual choice that affects neither the relevance instrument, nor the subsequent process.

Next, the AP has to assign an assessment weight to every objective. Now he uses as data the syllabus assessment scheme. There is a wide range of formats to communicate this information. Any of them is valid, provided that the final outcome yields a distribution of the total mark of the course over the objectives. Table 5 shows a hypothetical example where the total mark is distributed on different assessment instruments I_k, and these instruments are linked to the objectives in order to obtain their assessment weight, a_j.

3.2.2. Phase 2—Computation of relevance indicators

With the previous collected data, we can now produce the relevance indicators. We are going to describe each one of them together with its computation process. It should be

Table 4
Time distribution on objectives

Objectives	Contents-objectives						Computation	Objectives classroom time
	T_1	T_2	T_3	T_4	T_5	T_6		t_j
O_1						1	$12/4 =$	3
O_2				1		1	$2/2+12/4 =$	4
O_3	1	1	1		1	1	$2+4/2+4/2+2/2+12/4 =$	10
O_4		1	1			1	$4/2+4/2+12/4 =$	7
O_5				1			$2/2 =$	1
Total								25

Table 5
Assessment weight distribution on objectives

Objectives	Instruments						Objectives assessment weight
	I_1	I_2	I_3	I_4	I_5	I_6	a_j
O_1			5			5	10
O_2	2.5					5	7.5
O_3					5	5	10
O_4				1.25		5	6.25
O_5		5	5	1.25		5	16.25
Total							50

noted that these computations could be automatically generated.[1]

The first two indicators concern the identification of those columns (objectives) and rows (competencies) in the competencies–objectives matrix in which all cells are zeros. Thus we define:

- the *zeros on objectives indicator (Zero_O)* as the list of objectives that do not contribute to any competence and
- the *zeros on competencies indicator (Zero_C)* as the list of competencies for which there is no objective contributing to it.

In our example, we see from Table 2 that Zero_O $= \{O_1\}$ and Zero_C $= \{C_4\}$. It should not be seen as unusual that a syllabus includes objectives that do not contribute to any competence and competencies for which there is no objective contributing to it. As we have said before, there are several constraints on a syllabus design. Nevertheless, one could claim that these cases should be revised. In fact, the syllabus could be investing resources (e.g., course time) that are not related to their assigned competencies or could have overlooked some of those competencies. From now on we do not take into account the objectives and the competencies identified in the previous zeros analysis.

In order to grasp the way in which every objective contributes to the competencies it is linked to, we produce two more indicators. The first one, the *objective intensity indicator, Int*(O_j), is a triple

$$\mathrm{Int}(O_j) = (p_{3j}, p_{2j}, p_{1j}),$$

where p_{ij} is the frequency of links of strength i for objective O_j. In our hypothetical example, objective O_2 intensity is (0,1,1), given that it does not have links of strength 3, has one link of strength 2 and one link of strength 1 (see Table 6). The second value is the *objective density indicator, Dens*(O_j), that measures the number of competencies the objective is linked to (see Table 6).

These two indicators have their corresponding orderings. We say that objective O_i is more intense than objective O_j whenever O_i has at least one link that is stronger than any link of objective O_j. If both objectives have the same number of strongest links, then we look at the next link level. In our example, O_3 is the most intense objective, followed by O_2, O_5 and O_4. Concerning objectives density, we say that O_i is denser than O_j if O_i contributes to more competencies than O_j. For example, O_2 and O_5 are denser than O_3 and O_4.

Table 6
Intensity and density of objectives

Measures	Objectives			
	O_2	O_3	O_4	O_5
	1	0	0	0
	0	3	0	1
	2	0	1	1
Intensity	(0,1,1)	(1,0,0)	(0,0,1)	(0,0,2)
Density	2	1	1	2

Table 7
Intensity of contribution to competencies

Competencies	Objectives				Intensity
	O_2	O_3	O_4	O_5	
C_1	1	0	0	0	(0,0,1)
C_2	0	3	0	1	(1,0,1)
C_3	2	0	1	1	(0,1,2)

These two orderings provide information concerning how the objectives are set up from the point of view of the competencies. We see, for instance, that there are objectives in every intensity level; that there is only one objective, O_3, in the most intense level and that it is low in density (therefore its contribution is concentrated on one competence); and that objective O_4 occupies the last place of the two orderings (hence, this is the only objective that contributes poorly to the competencies).

The last indicator that we obtain from the competencies–objectives matrix is the *intensity of contribution to competencies indicator* of a competence C_i. It is a triple

$$\mathrm{IntCC}(C_i) = (q_{i3}, q_{i2}, q_{i1}),$$

where q_{ij} is the frequency of links of strength j for competence C_i (see last column of Table 7). For instance, IntCC$(C_2) = (1,0,1)$, which means that C_2 is being worked through two objectives, with a strong link with one of them. We arrange these triples in the same way that we ordered the intensity of objectives indicator. We see in our hypothetical example that C_2 has the highest intensity, followed by C_3 and then C_1.

Besides the previous indicators, based only on the direct links between objectives and competencies, we are going to take into consideration other values that grasp how the objectives are worked out in the syllabus. For this purpose,

[1]An Excel file for this purpose can be downloaded at: http://personales.unican.es/gonzalelm/index_archivos/relevanceAssmt.xls

we are going to compute one more indicator involving the syllabus' contents calendar.

Considering the time distribution values obtained in phase 1, we can transfer the collected time information on the objectives to the competencies list. Thus, we define the *time indicator* of a competence C_i as

$$\mathrm{Time}(C_i) = \sum_{j=1}^{n} t_j t_{ij},$$

where $t_{ij} = 1$ if its corresponding value s_{ij} in the competencies–objectives matrix is bigger than 0, and $t_{ij} = 0$, otherwise. The time indicator is a measure of the total time expected to be devoted to each competence in the syllabus. In our hypothetical example, we obtain the values shown in the second column of Table 8.

With these single numerical values, we can produce a direct competencies' ordering: C_3 with the highest time, then C_2 and finally C_1. This ordering complements the intensity of contribution to competencies ordering proposed above, as we are using complementary information sources to produce them.

A syllabus has several interrelated components that should be coherent among them. If this is the case, then one can choose any component in order to characterize the syllabus' contribution to a list of competencies. From those components easily available in a syllabus' documents, we have chosen the time spent on each competence. But then, in order to assess the relevance of a course through the time indicator, one should add some coherence measurement. For that purpose, we take into account the assessment weight on objectives as another component that is readily available in the syllabus' documents. We propose two indicators—correlation and residuals—to measure the extent to which the time indicator and the assessment weight are coherent between them.

These two indicators use in their computation the *assessment weight* of a competence C_i, that is:

$$\mathrm{Ass}(C_i) = \sum_{j=1}^{n} a_j t_{ij}.$$

The value $\mathrm{Ass}(C_i)$ measure the syllabus' contribution to the competence C_i in terms of its importance in the assessment scheme of the course. The third column of Table 8 shows the values for the hypothetical example.

With these values we first compute the *correlation indicator*, that is, the correlation coefficient of the time indicator and the assessment weight of competencies. If this value shows a lack of or negative correlation, a global incoherence is detected in the syllabus design that must be interpreted in detail before continuing with the rest of the analysis. If a high positive correlation is obtained, then we carry out a finer analysis on each competence. For this purpose, we perform a regression analysis on the time and the assessment variables, considering that time is the explanatory variable upon which assessment depends linearly. This analysis produces the *residual indicator, Res(C_i),* of every competence C_i. The value $\mathrm{Res}(C_i)$ is the standardized residual of C_i, that is, the difference between the expected assessment value and the actual value. This indicator highlights the *outliers* in the competencies list, that is, those competencies whose residual indicator is big enough. As usual for this kind of standard Gaussian distribution, we will consider that a competence is an outlier when its residual indicator is bigger than 2 or smaller than −2. Detailed explanations for these competencies are required. In our example, the correlation indicator is close to one (0.9991) and there are not outliers (see last column of Table 8).

Table 8
Time indicator and residual indicator computation

Competencies	Time(C_i)	Ass(C_i)	Expected Ass(C_i)	Residuals	Residual indicator Res(C_i)
C_1	4	7.5	7.43	0.07	0.13
C_2	11	26.25	26.78	–0.53	–1.06
C_3	12	30	29.54	0.46	0.93

3.2.3. Phase 3—Results interpretation

The results of the computations we have just described have to be interpreted. In what follows, we suggest some procedures for such an interpretation. We consider each of the three dimensions into which the relevance indicators are organized.

In the first dimension, the zeros on objectives, the intensity and the density indicators characterize the relevance of a syllabus in terms of the potential contribution of its objectives to the development of the competencies. With the information provided by these indicators, it is possible to produce orderings that indicate how and to which extent each objective is linked to the list of competencies. The analysis can include the identification of those objectives that are in the top, middle and bottom of each list. The orderings can be compared, looking for those objectives that appear on the same section of both orderings and those that appear in two different extremes. Objectives in the top of both lists highlight foci of the syllabus in its contribution to the competencies, while the weak objectives are those sharing the bottom sections. Objectives appearing in two different extremes have to be analyzed: for instance, an objective with high density but low intensity might represent the syllabus' purpose of developing a transversal skill. When no satisfactory explanation is obtained, some improvement can be suggested. In the next section we show concrete conclusions that can be achieved on a real case.

In the second dimension, the zeros on competencies, the intensity of contribution to competencies and the time indicators characterize the contribution of the syllabus, as a whole, to the potential development of the competencies. These indicators can provide useful information for the revision of the syllabus' objectives or calendar. Besides

Table 9
Itermat competencies

Competence	Description
C_1	Link mathematical content to physical, biological, economic phenomena; recognize formal aspects involved in problem modelling.
C_2	Know mathematics learning theories.
C_3	Analyze critically and assess syllabi and curriculum proposals.
C_4	Recognize students' types of reasoning, diagnose their errors and propose tasks to guide their learning processes.
C_5	Select and put in sequence learning activities; analyze the diverse problems that arise in learning situations.
C_6	Design, select and analyze didactic units, textbooks and didactic resources.
C_7	Make use of specific criteria, techniques and instruments to assess mathematical knowledge.
C_8	Know didactical resources and materials; know how to use them in teaching activities.
C_9	Use communication skills to provide meaning to mathematical concepts.
C_{10}	Develop students' mathematical empowerment and promote society's positive attitudes towards mathematics.

identifying those competencies to which the syllabus does not contribute to, one can analyze the two orderings (intensity and time) in a similar manner as the one proposed for the density and intensity of objectives. That is, one can analyze how the syllabus is expected to contribute to those competencies that appear in the bottom part of the time and intensity of contribution to competencies orderings, and those competencies that appear in two different extremes of those orderings. This analysis can imply the need for looking back at either the competencies–objectives matrix, or the time distribution on objectives and the syllabus calendar. At the end, one can identify objectives and competencies whose links have to be looked at and explained.

In the third dimension, the correlation and residuals indicators provide information about the coherence of the calendar and the assessment scheme of the syllabus in terms of their contribution to the development of the competencies. Finding a low correlation indicator implies the need of revising how the calendar (content) and the assessment scheme are setup within the syllabus. For the competencies identified as outliers, one should analyze its corresponding row in the competencies–objectives matrix, and find explanations for the incoherence between the time devoted to its development and its importance in the assessment scheme.

The interpretation of results involves two steps: characterizing the syllabus in terms of its relevance and providing explanations for some of those characteristics. In general, the second step implies analyzing the original data. This data revision might inform the AP that he has introduced some inaccuracies when collecting them and that he should make the appropriate corrections. Hence, the instrument can be used in a cyclic manner of design and revision.

4. Assessing the relevance of a mathematics methods course

In the Spanish context, the standards move in mathematics teacher education settled on the Itermat competencies list. This list was defined within the Itermat Seminar organized by the Spanish ICMI Committee and the University of Granada (Recio, 2004). We consider that, up to the moment, it constitutes a valuable reference document representing the consensus of the institutions involved. The Itermat competencies list is split in two parts. The first part contains those competencies that should be acquired after a whole training program; the second part consists of more local competencies that should constitute the purpose of a methods course. We focus our example on this second part (see Table 9).

The course named *Didactics of Mathematics in Secondary Education* appears in the current mathematics degree of different Spanish universities. It is usually followed by students who have in-depth understanding of formal mathematics and who consider the teacher profession as their future occupation. Different universities are adopting different syllabi for this course; all of them can be considered starting points in the definition of new courses adapted to the HEES requirement.

We are going to develop our example by considering the concrete syllabus for this course described in the list of objectives of Table 10. The other syllabus components will be described through this section. This syllabus was used as a prototype in a research project[2] developed by the authors of this paper. Therefore, the assessment team was composed by a group of researchers, some of whom played also the role of teachers of the course.

We devote the rest of this section to exemplify the assessment of the relevance of this course with respect to the Itermat list.

4.1. Phase 1—Data collection

Considering the objectives and the competencies lists, the AP fills in the competencies–objectives matrix shown in Table 11. The empty cells correspond to zeros. Although all these assignments have to be justified, we just show here a couple of them in order to spare tedious explanations.

The AP considers that objective O_7 is strongly linked to competence C_8 as both texts point to the same topic with the same purposes. However, O_7 is weakly linked to C_7

[2]Proyecto BSO2002-02799 del Ministerio de Ciencia y Tecnología: *Indicadores de calidad para la formación inicial de profesores de matemáticas*.

Table 10
Syllabus objectives

Objectives	Description
O_1	Know literature research on mathematics curriculum. Know antecedents, foundations and development of the current Spanish mathematics curriculum.
O_2	Know and analyze the purposes of mathematics education.
O_3	Establish foundations for mathematics curriculum in Secondary Education, analyze its dimensions and levels.
O_4	Know recent innovative curriculum processes. Know the structure of the current mathematics curriculum design.
O_5	Know the different conceptual fields organizing the design, development and assessment of the Secondary Education mathematics curriculum.
O_6	Put in context the learning of mathematics learning taking as reference the main learning theories.
O_7	Know didactical materials, books and usual resources for the learning of mathematics. Know methods and selection criteria.
O_8	Establish conceptual frameworks to organize school mathematics curriculum. Study and exemplify the mathematics curriculum organizers.
O_9	Develop pedagogical content knowledge and use this knowledge to analyze mathematical contents.
O_{10}	Gather and structure curriculum organizers information on concrete mathematical contents of Secondary Education.
O_{11}	Design a mathematics didactic unit based on the collected organizers' information.
O_{12}	Connect future teachers with the mathematics education community and its communication means.
O_{13}	Analyze, synthesize and review different types of documents and communicate the results.
O_{14}	Organize and manage efficiently a working group.
O_{15}	Develop self-critical abilities on the own work and on the work developed by the group in which everyone has participated.
O_{16}	Develop critical abilities to evaluate other people work.
O_{17}	Communicate orally and in writing the results of the different course works.
O_{18}	Use technological means to communicate.

Table 11
Competencies–objectives matrix

Comp	Objectives																	
	O_1	O_2	O_3	O_4	O_5	O_6	O_7	O_8	O_9	O_{10}	O_{11}	O_{12}	O_{13}	O_{14}	O_{15}	O_{16}	O_{17}	O_{18}
C_1								1	1	1	2			1				
C_2						3					1			1				
C_3				3								1	2				1	
C_4						2					3			1				
C_5										2	3			1				
C_6				1							3			1				
C_7							1				3			1				
C_8							3				3							
C_9																2		2
C_{10}											1							

because the AP considers that C_7 is just one of the multiple requirements needed for the development of O_7.

Objective O_{11} has been related to most of the competencies. In fact, this objective is linked to multiple students' activities distributed along the course, which are captured, at the end of the course, in a final work. In this final work, the students produce and justify an original didactical unit, putting into practice almost all the aspects treated in the course. Regarding the competencies list, the AP finds that C_6 corresponds almost literally to O_{11}; besides, competencies C_4, C_5 and C_7 are strongly involved with the planning of classroom tasks described in O_{11}. Therefore, these four links have been fulfilled with the maximum value 3. The AP also considers that C_1, C_2 and C_{10} are some of the (many) previous steps worked out by the students to prepare the didactical unit. For this reason they are linked with the minimum value 1.

In order to get the classroom time and the assessment weight distribution on objectives, the AP uses the syllabus' contents calendar and assessment scheme. In this example a total of 92 classroom time hours and a total mark of 100 points are distributed, obtaining the results shown in Table 12.

4.2. Phase 2—Computation of relevance indicators

Once all these data are collected, the computation of the different indicators gives us the following results that will be interpreted in phase 3:

$$\text{Zero_O} = \{O_1, O_2, O_3, O_5, O_{15}\},$$

$$\text{Zero_C} = \varnothing.$$

The objectives' intensity and density orderings are shown in Tables 13 and14, respectively. Tables 15 and 16 show the

Table 12
Time and assessment distribution on objectives

Objectives	t_j	a_j
O_1	10	5.60
O_2	3	0.00
O_3	3	5.00
O_4	4	5.00
O_{15}	8	3.10
O_6	8	1.49
O_7	7	0.36
O_8	8	6.19
O_9	8	8.69
O_{10}	8	16.01
O_{11}	20	8.33
O_{12}	5	0.00
O_{13}	0	0.00
O_{14}	0	15.24
O_{15}	0	2.50
O_{16}	0	6.67
O_{17}	0	9.17
O_{18}	0	6.67

Table 13
Objectives' intensity ordering

Objectives	Intensity
O_{11}	(5,1,2)
O_6	(1,1,0)
O_7, O_4	(1,0,1)
O_{10}	(0,1,1)
O_{13}, O_{16}, O_{18}	(0,1,0)
O_{14}	(0,0,6)
O_8, O_9, O_{12}, O_{17}	(0,0,1)

Table 14
Objectives' density ordering

Objectives	Density
O_{11}	8
O_{14}	6
O_4, O_6, O_7, O_{10}	2
O_8, O_9, O_{12}, O_{13}, O_{16}, O_{17}, O_{18}	1

Table 15
Intensity of contribution to competencies ordering

Competencies	Intensity
C_8	(2,0,0)
C_3	(1,1,2)
C_4, C_5	(1,1,1)
C_2, C_6, C_7	(1,0,2)
C_9	(0,2,0)
C_1	(0,1,4)
C_{10}	(0,0,1)

syllabus' intensity of contribution to competencies ordering, and the time indicator ordering, respectively. The correlation coefficient of the time indicator and the assessment weight of competencies are 0.7085. Table 17 shows the assessment weights and residuals.

Table 16
Time indicator ordering

Competencies	Time
C_1	44
C_2, C_4, C_5	28
C_7, C_8	27
C_6	24
C_{10}	20
C_3	9
C_9	0

Table 17
Assessment weights and residuals

Competencies	Ass(C_i)	Res(C_i)
C_1	54.46	1.25
C_2	25.06	−0.29
C_3	14.17	0.25
C_4	25.06	−0.29
C_5	39.58	1.14
C_6	28.57	0.39
C_7	23.93	−0.31
C_8	8.69	−1.81
C_9	13.34	0.92
C_{10}	8.33	−1.25

4.3. Phase 3—Results interpretation

The AP reports the following characterization of the objectives' expected contribution to the development of competencies—the first relevance dimension.

This syllabus includes an important number of objectives, 5 out of 18, not contributing to any competence. Regarding these objectives, four of them (O_1, O_2, O_3, O_5) are related to conceptual curriculum aspects. Therefore, this syllabus emphasizes theoretical curriculum questions, while their assigned competencies focus on the curricular aspects from a more practical perspective.

There is just one objective (O_{15}) not considered in the course competencies list. It addresses one question related to interpersonal competencies, which is secondary in a competencies list more involved with subject specific knowledge.

There is one objective (O_{11}) in the first place of the intensity and density orderings (Tables 13 and 14). It is linked to eight (out of ten) competencies with strong intensity in five of them. This result shows a clear emphasis of the syllabus on this objective and illustrates a connecting thread that guides this syllabus contribution to the competencies. The middle places of the ordering lists share a block of six common objectives (O_7, O_4, O_{10}, O_{13}, O_{16}, O_{18}). This syllabus has, therefore, an important number of

objectives matched up in an almost one-to-one way with some competencies, but just partially contributing to them. In the last place of both lists there is an important number of objectives (O_8, O_9, O_{12}, O_{17}). Objectives O_{14} and O_6 are unequally placed in Tables 13 and 14 orderings. O_{14} description shows that it addresses a transversal skill involved in most of the course homework. Therefore, it is natural for it to be linked to many competencies, not strongly with any of them. The case of objective O_6 has also a satisfactory explanation, as it corresponds to an objective directly concentrated on two competencies with high intensities.

From these remarks on the first dimension we may conclude that:

- A better correspondence with the syllabus assigned competencies could be obtained by reinforcing its commitment with practical oriented curricular questions.
- A reformulation of some objectives in the medium section could increase the density of transversal objectives (O_{13}) and the intensity of objectives focused on specific contents (O_{10}).
- Objectives included in the bottom places of both lists (O_8, O_9, O_{12}, O_{17}) have to be revised on the basis of a more profound knowledge of the syllabus in order to clarify if they have been wrongly considered in the data collection phase (perhaps new links in the competencies–objectives matrix are found) or to determine some improvement proposals for them.

Concerning the syllabus' global contribution to the competencies—the second relevance dimension—the AP realizes several remarks.

The syllabus contributes to all the competencies.

The time indicator ordering shows a time interval (from 20 to 28) that groups an important number of "time-similar" competencies (seven out of ten). In this block there is just one remarkable fact: competence C_{10} has an excessive time comparatively to its corresponding intensity, as it is weakly linked to just one objective. The intensity of contribution to competencies ordering shows that almost all the competencies (seven out of ten) are tackled with the highest possible level of intensity.

Competence C_9 is linked to two objectives with considerable intensity. However, it has no time assigned. These objectives have zero classroom time assigned as it is expected that they will be developed through the course homework. Competence C_3 is in the bottom section of the time ordering, but in the top section of the intensity ordering. Looking at its objectives' links, it is noticed that most of the syllabus time devoted to the development of this competence comes from a strong link with just one objective. Competence C_1 stands out in the time ordering list. It is linked to five objectives—which partially justifies this data—but with the lowest intensity in four of them.

From these remarks on the second dimension, we may conclude that:

- The rewriting of some objectives (O_9, O_{10}), dividing them in more concrete facets susceptible of being linked to competencies with high intensity and suitable time, could improve their correspondence to the competencies list.
- The non justified excessive time devoted to some competencies (e.g., C_{10}) could be revised in order to determine, taking into account some additional information, if a reallocation of data has to be made in the data collection phase or if some improvement proposal can be made.

Concerning the coherence dimension, there are no remarkable facts.

5. Discussion and lessons learned

We have introduced a meaning for the notion of relevance of a course through the relevance assessment instrument. The set of indicators we have produced provides information for characterizing a syllabus in terms of a list of competencies. It pinpoints those features of the syllabus in which there is room for improvement, as we have shown in the example presented. On the basis of the information provided by the instrument, one can determine how and to what extent each objective is linked to the list of competencies; establish how the syllabus seeks to develop each competence; identify objectives and competencies whose links must be examined and explained; and determine those cases for which organization of the calendar (content) and the assessment should be checked. In summary, with the help of the relevance assessment instrument one can not only establish the extent to which a syllabus and a list of competencies are aligned, but also ascertain those aspects of the syllabus for which improvements can be made. All three results occurred when we assessed the relevance of the course that we used in the example above. The instrument highlighted aspects of a syllabus that were not evident to us as syllabus designers and corroborated intuitions about the syllabus for which we had not previously had any solid evidence. Furthermore, the instrument indicated where and how we could change the course syllabus to produce a better alignment with the selected list of competencies.

Whether learners in a course actually develop a given list of competencies is a complex issue that involves questions of developing and assessing competencies, questions that we do not tackle in this paper. The purpose of the assessment instrument we have proposed is less ambitious. It provides information concerning to what extent a course, as described by its syllabus, may potentially promote the development of a list of competencies. If by applying the instrument one finds that a course aligns with a set of competencies, this does not necessarily imply that, when the syllabus is brought into play in the course development, learners will actually develop those competencies. The

learners' success in this will depend on many factors, including the actual learning activities proposed to them and the actual performance of the teacher in class. Therefore, the relevance of a course is not a sufficient condition for the learners' development of competencies. Nevertheless, we feel that it can be considered to be a necessary condition. If a syllabus is not relevant to a set of competencies, it is very unlikely that, when that syllabus is implemented, learners will develop those competencies. From this viewpoint, the relevance of a course can be considered a quality dimension in the quality assurance perspective, since the course design—in particular, the coherence of time, content and assessment in the course syllabus—can have an impact on the learners' achievement.

The consequences derived from the results of analysing relevance depend on the AP's knowledge of the course. We consider that the process of assessing the relevance of a course rests firmly on expert judgment, although future work is required to precisely determine the extent to which the AP's assistance and skill affect the alignment outcomes. We suggest that data should be collected on the basis of the syllabus documents and by experts that can make the appropriate interpretation of those documents.

Interpreting the results requires going back to how the indicators were computed, and therefore to how and why the data was collected. Because a syllabus is a complex design, it is not easy to cover its whole structure at a given moment in time. Therefore, the AP may introduce partial inaccuracies when collecting some of the data. The analysis and interpretation of the results obtained with the relevance assessment instrument can highlight these imprecisions and induce the AP to reconsider the original assignments.

The application of the instrument imposes very weak conditions on the information needed about the syllabus: the list of objectives, the calendar, and the assessment scheme of the course. This means that the instrument can be applied to most syllabi on any subject for which there is a list of competencies. However, if further information is available, the instrument can be used in other ways. For example, if there is a structure organizing the list of objectives and/or the list of competencies, objectives and competencies could be grouped in categories and the relevance indicators computed on those categories. There might also be more than one list of competencies to which a syllabus could refer. For instance, in the case of the European Higher Education Area, different stakeholders (academics, employers and graduates) have produced different lists of competencies for each profession. The criteria that we have proposed can, therefore, be used to compare the characterizations of a syllabus corresponding to each list of competencies.

The interpretation of results we have presented for the mathematics teacher education course has served its teachers to produce a more relevant syllabus with respect to the Itermat competencies. Further work is currently being developed, including efficacy and efficiency studies, to determine this course contribution to the competencies development.

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