

# The challenge of discovering the threshold concepts of medical research areas: a bibliometrics-based approach

A. Santisteban-Espejo<sup>1</sup>, J.A. Moral-Munoz<sup>2,3\*</sup>, M.A. Martin-Piedra<sup>4,5</sup>, A. Campos<sup>4,5</sup>

## Abstract

During the last XX century, several changes were applied to traditional educational methods, positioning the student as a central actor in the learning process. One of the pedagogical theories developed was the Threshold Concepts (TC) educational framework, based on education as a space of uncertainty, where the student needs to learn a certain concept or learning experiences that allow developing a new way of thinking. In medical education, written accounts about significant learning experiences, analysis of practice essays and semi-structured focus groups interviews have been applied to identify TC. In that way, our hypothesis is that the use of bibliometrics, as a tool to discover hidden relations between keywords, can overcome traditional difficulties related to TC identification. Keywords are applied to highlight the content of a digital object; they are concepts with a special meaning, similar to TC. Our challenge is to identify the bibliometric indexes that are able to show the relationship between the keywords that make them TC, especially in a medical context. In previous scientific literature, several methods were applied, mainly based on qualitative assessment. In this sense, we propose a quantitative, objective, and reproducible approach that can enrich the learning process from a scientific-based perspective.

## Keywords

Bibliometrics — Biomedical research — Learning

<sup>1</sup> Division of Hematology and Hemotherapy, Puerta del Mar Hospital, Cadiz, Spain

<sup>2</sup> Department of Nursing and Physiotherapy, University of Cadiz, Cadiz, Spain

<sup>3</sup> Institute of Research and Innovation in Biomedical Sciences of the Province of Cadiz (INIBICA), University of Cadiz, Cadiz, Spain

<sup>4</sup> Tissue engineering group, Department of Histology, University of Granada, Spain

<sup>5</sup> Instituto de Investigación Biosanitaria ibs.GRANADA, Spain

\*Corresponding author: joseantonio.moral@uca.es

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## Background

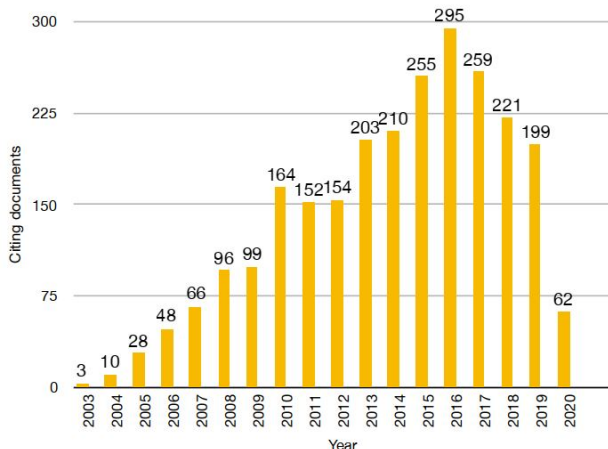
Several pedagogical theories have been developed over the last XX century. As the educational community took into consideration the frailty of traditional methods to overcome globalized challenges, new approaches emerged [1]. Overall, they are characterized by the central positioning of the student in the learning process and the rejection of the vertical replication of knowledge [2]. In this context, Freire's pedagogy of freedom [3], Piaget's operative model [4] and constructivism

principles [5] were also applied. Nevertheless, the need to entail novel discourses about disciplines and to foster a critical view of reality for students have led to the Threshold Concepts (TC) educational framework.

TC pedagogical theory was proposed by Meyer and Land in 2003, and it has been attracting the attention of the scientific community during the last two decades (Figure 1). Their theory is based on the notion of education as a space of uncertainty [6]. It lies in the existence of certain concepts or learning experiences that resemble conceptual gateways or portals that lead to a previously inaccessible way of thinking about something [7]. According to Meyer and Land, TC have some characteristics in common. They are *transformative* because once understood, they trigger a significant change in the student's perception of a subject. This epistemological shift involves emotional and performative elements of the learning process [8,9]. The acquisition of TC is also *irreversible* because once learned they are unlikely to be forgotten by students; and they are *integrative*, as they expose previously hidden interrelatedness between apparently distant disciplines. TC are also *troublesome* for learners because their learning is

perceived as difficult or dissonant [6].

TC-based teaching constitutes an effective strategy for the improvement of student's learning. In this sense, since the original description of TC, they have been applied to the field of economics [10], engineering [11] and physics [12], among others. However, the literature of TC in medical education still remains scarce, as stated by Gaunt and Loffman [13]. In this regard, qualitative methodologies have tried to identify medical TC by means of written accounts about significative learning experiences [14], analysis of practice essays [15] and semi-structured focus groups interviews [16]. Nevertheless, medical TC definition is limited because of methodological heterogeneity and, thus, a lack of uniformity and within qualitative research. Randall et al. identified notions as *"Being smart isn't enough"*, *"It's about the patient"* or *"Medicine isn't black and white, but almost always grey"* as TC for students in a paediatric clerkship [15]. A research conducted by O'Callaghan and colleagues defined five TC for palliative medicine: "Emotional Engagement", "Communication Management", "Embodied Shared Care", "Active Inaction" and "Uncertainty Embraced" [16]. In General Practice, Vaughan developed the idea of vocational threshold and proposed that medical TC are tied with dispositional attributes more than with the acquisition of skills or pieces of clinical knowledge [10]. In this regard, medical TC could contribute to explore new spheres in medical education and to improve students learning in critical points of special difficulty. Moreover, they can inform lecturers for the course and curricula design [17]. Nevertheless, one of the essential obstacles that remain unsolved is that of medical TC recognition.



**Figure 1.** Citing documents to the main papers about TC by Meyer and Land [6, 7, 18–21].

## 1. The hypothesis

Bibliometrics, as a part of the scientometrics (the quantitative study of science), is the research on scientific communication, analysing specifically data from publications, citations, and journals. Concerning the nature of the TC, they are words or a

set of words that have a special meaning in a particular context, which is the learning subject. In that way, this definition seems to be similar to a keyword, used in the computer language to highlight the content of a digital object. In bibliometrics, the keywords are one of the analysing units which we can work with to discover the hidden relations behind scientific production. Therefore, we would think that bibliometrics can be applied to solve some traditional difficulties associated with the field of the TC identification in a particular discipline, as medicine.

Robert Daniel and Chauncey Louttit, at the beginning of the 1950s, constructed the first science map for the field of psychology to show its development based on structures hidden in the literature [22]. They composed a journal-to-journal-citation matrix and calculated similarity measures and applied cluster analysis. All this was done by hand. Fortunately, those relations are now registered by the bibliographic databases. The creation of the Science Citation Index (SCI) by Eugene Garfield was the milestone that triggered the development of the science of science [23]. SCI was the predecessor of the Web of Science and it is one of the most important bibliographic databases worldwide. Nowadays, there are other databases, such as Scopus, Dimensions, Microsoft Academic or Google Scholar, that provide access to bibliometric information [24]. In short, they offer the possibility of discovering the relationships that exist between the different scientific analysing units, including the keywords.

A keyword is an attribute of the scientific document, but a document can have a defined number of keywords. Nonetheless, all these keywords cannot be TC in the scientific field. Due to this issue, advanced bibliometrics methods may be used to achieve the goal of discovering the special characteristics of a keyword and to give it the status of TC. The relative importance of the keywords can be discovered by means of the two main methods in bibliometrics, performance analysis and science mapping [25]. Those techniques could offer us the way to measure the importance of a word in a context, analysing the strength of the relations between attributes, in this case, keywords. These relations conform to a bibliometric network that used to be weighted and the most common are based on relations of citations, keyword co-occurrences and co-authorship [26]; although the first two seem to be the most useful to our purpose.

## 2. Evaluation of the hypothesis

Several methods have been reported in the previous scientific literature. These methods are mainly based on qualitative assessment. However, none of them provides an objective, reproducible and quantitative approach. In this regard, the proposed hypothesis supposes a new insight into TC identification.

### 2.1 Methods for identification of threshold concepts

TC have emerged as a relevant tool for a focused curricular redesign as the teaching of these notions may significantly

improve the students' learning about crucial aspects of each discipline [27]. Thus, an important widespread of TC since its definition is remarkable during the last years. However, previous to the use of TC for the improvement of teaching and learning, it is yet to solve the question about how to identify such concepts.

There have been described several methodological strategies with the purpose to identify TC. First attempts consisted of a fluid framework based on asking scholars to identify themselves TC in their subjects [28] or the discussion between partners [29]. These scholar-based approaches present some limitations. Firstly, there was observed high variability as more than 40 TC were identified, but only eight of them were proposed by five or more consultants. This heterogeneity may arise from the TC definition as it is not yet clear enough the difference between a core concept (a key notion in the discipline learning) and a genuine TC.

TC identification has also been assessed in a retrospective insight by analysing past examinations to students with some questions addressing such TC [28]. Strikingly, interesting results were obtained as a bimodal distribution explained the results, suggesting a relation between marks and the integration of TC. Those students who were integrating TC, tended to obtain better marks than those who were not. These approaches use only the academic profile for the identification of TC, whereas students are merely spectators. However, academics have understood all TC time ago, so they might not be accurate subjects to assess some characteristics used to define TC, such as troublesomeness, suggesting that students should be an active part of the TC identification method.

There have also been reported studies trying to evaluate the troublesomeness by students [30, 31]. Many of these studies used students to confirm whether certain concepts previously selected in collaborative workshops of experts could be considered as TC or not. Moreover, sometimes selected items were refined by analysing the ideas unlocked once understood and the hidden connections before understanding [30].

Among studies that focused on students, not only for confirmation but also for identification of TC, it can be highlighted by the study by Carstensen and Bernhard [32], who used video analysis in a lab setting where students were recorded in a real scenario while arguing about TC. Authors aimed to observe not only troublesomeness in students about certain concepts but also the relationships they establish among them, thus studying also integrative and bounded characteristics proposed by Meyer and Land [6]. The strong point of this approach is not only the student participation, but also the immediacy that could be useful for identification in hindsight (interviews provide a retrospective point of view). There are several authors that prefer the narrative instead of semi-structured interviews as an adequate method when looking for troublesomeness as they allow the students to present their particular stories [33], with no expectations of particular content or answers. Nevertheless, found troublesomeness is not only indicative of a TC as it could also be detected due to a

lack of effort or motivation in the students.

The analysis of students' expression has also been used in the healthcare sciences. The description of critical incidents during clinical practice by nursing students have led to suggest "*caring*" as a troublesome notion that it is also transformative once understood [34]. These kinds of fluid strategies are not accurate enough but could act as a trigger for TC identification.

Undoubtedly, the task of finding TC in a discipline is difficult and there is no gold-standard technique to this goal. However, the collaboration between students and teachers seems to be an adequate approach that may provide higher rigour in TC identification. Even, Cousin [35] proposed the "*transactional curriculum inquiry*" as coordinated crosstalk among students, academics and also education developers as an effective partnership at this purpose. A collaborative international project coordinated by the University of Western Australia aimed to use this transactional curriculum inquiry approach in the engineering field [36]. The strategy consisted of a two-phase workflow, one consisting of single subjects analysis and a second integrating phase when academics and students of different institutions focused on the interdisciplinary interactions. This strategy allowed high accuracy in the identification of 5 to 13 TC. This range was due to some discrepancies between participants.

All these findings arise the need for a methodological consensus via multidisciplinary and collaborative participation, involving both students and academics, as well as education developers [37, 38]. Moreover, Barradell stated that transactional curriculum inquiry should also be extended to the professional community: "*Given that threshold concepts are bounded and linked to the practice and thinking of each discipline, the discourse should naturally extend beyond the teaching and learning environment to the wider professional community*" [37]. Professionals are also aware of those notions that imply troublesomeness and personal transformation in a way that may be unforgettable (irreversible). Thus, the professional community should also be included in the identification process of the TC.

Although there are some differences among disciplines, scientific literature uses to be one of the mainstreams of communication within the professional community, especially in the case of Medicine and Healthcare Sciences. This fact opens a new horizon in the strategies trying to locate TC. Our hypothesis is based on the role of the scientific production reported by an area of knowledge whose teaching needs to be designed at the present moment, as it is the case of tissue engineering [39, 40].

Bibliometric analysis could be used for the isolation of some notions that gather a great effort on research. These hotspots may represent some problems or concepts that are difficult —*troublesome*— but worthy to solve for the progress of the discipline —*transformative*—. Often, the solving of these problems require the collaboration of different fields around some shared concepts —*integrative*. Thus, research

mainstreams present some features that are closely related to those of TC, suggesting that bibliometric analysis could arise as a new objective, reproducible and quantifiable tool that may be used as a methodological strategy in the identification of TC.

### 3. Consequences of the hypothesis and discussion

In conclusion, we elucidate the application of bibliometrics as a base for a new methodology for the identification of medical TC to better adjust course and curricula design to the inherent complexes and uncertainty conditions of the current medical profession. In comparison with qualitative methods, our approach is grounded in bibliometrics and it constitutes a quantitative, objective, and reproducible procedure. Thus, medical lecturers could also explore the pedagogical applications of data contained in scientific documents (i.e. keyword analysis) and to implement them at university and research levels.

It would be worthy to apply this original approach in the field of advanced therapies and, specifically, in tissue engineering. Advanced therapies and tissue engineering are multidisciplinary research areas whose aim is the development of new clinical applications. In this sense, artificial tissues developed by tissue engineering may be applied for the management of previously untreated diseases and injuries. Thus, these new applications broaden the knowledge base of the medical education, and consequently the clinical practice; entailing the need to translate this new knowledge to the current medical curricula. Moreover, their wide development requires the identification of the specific TC in order to base the curricula design of medical education.

We hope to contribute in this way with the improvement of medical education and to offer useful educational tools to the teaching and medicine community.

### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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