Technology Enhancing Learning: Past, Present and Future.

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Abstract. Every year the European Conference on Technology Enhanced Learning (ECTEL) gathers state-of-the-art research in the TEL field. Eight years have passed since the first edition of this conference, resulting in over 500 research papers published and more than 1000 researchers involved. However, bringing together two different fields of study (Technology and Learning), does not necessarily imply interdisciplinary research. To inspect ECTEL's interdisciplinarity and related facts, we dedicate this paper to study the evolution of the conference over time. In this paper, we provide a thorough analysis of the evolution of papers, authors and topics explored over the years. Our analysis provides an understanding of the origin of the conference and the direction that future research in TEL is moving towards. In addition to this, we built interactive online interfaces to enable researches to explore all the information pertaining to past ECTEL research. These interfaces enable users to easily browse through ECTEL papers, authors, knowledge and connections, possibly leveraging the discovery of related work and future collaborations.

1 Introduction

Every year since 2006, the European Conference on Technology Enhanced Learning (ECTEL) has been gathering the elite research papers and researchers in the field of *technology* and *learning*. Since its first year, the conference has had a clear goal; to bring together researchers from the fields of technology and learning, and provide a discussion forum to blend both fields [13]. In fact, year after year, the conference is successfully achieving its founders' vision. In eight years of this conference, over 500 research papers have been published with more than 1000 authors involved.

However, bringing together two different fields of study does not necessarily imply interdisciplinary research. Although many papers provide a fine balance between technological and learning advance, browsing past proceedings we can clearly observe papers that are mainly focused on learning aspects, e.g. [7, 11], and papers that improve the state-of-the-art technology but are not strictly linked to learning scenarios, e.g. [8, 3].

In addition to this observation, during the ECTEL 2013 conference, we informally interviewed several attendees who have confirmed witnessing a gap between learning

and technology within the conference. These observations motivated us to explore the past, current and future standing of ECTEL conference.

Since the main goal of ECTEL is to augment the interdisciplinarity between technology and learning, we believe that, by supporting researchers from both fields in easily finding and exploring past elements of the venue, we can significantly contribute to achieve this goal.

In this paper, we present a thorough analysis of eight years of ECTEL, including general statistics of the conference, distinctive analysis of the learning and technological fields, co-authoring analysis, community evolution, conference topic evolution among other interesting facts.

The metadata were extracted from ECTEL Webpages[1], the DBLP Computer Science Bibliography[2], and the Digital Library of Springer[3]. Further, all papers were downloaded in PDF format, converted to text and semantically annotated using the Wikipedia Miner tool [12].

In addition to the data analysis, we provide first results in the direction of predicting new community members and *hot* topics. Finally, to conclude our work, we provide an online interactive interface where researchers and everyday users can browse contents of ECTEL. The interface provides an easy-to-use interactive overview of the conference statistics, authors' profiles, collaborations network, keywords and annotations. Users can browse through the different pages, finding interesting papers, relevant related work and potential collaborations.

To summarize, our main goal is to provide a settlement between technology and learning, thus, the main contributions of this paper are outlined as follows:

- (i) An analysis of all ECTEL research works published to date.
- (ii) Annotated data of all the content from ECTEL papers.
- (iii) Feature selection for predicting new community members and conference *hot topics*.
- (iv) Online interactive interfaces to support the exploration of ECTEL data.
- (v) Exposure of all free available data to the Linked Open Data cloud for re-use.

The rest of this paper is structured as follows. In Section 2 we discuss past literature related to our work. Section 3 is dedicated to explain the data collection process and the analysis of interesting facts pertaining to past editions of ECTEL. In Section 4, we present experiments done in the direction of predicting future community members and popular topics in the conference. In Section 5, we briefly describe the user interfaces that enable users to browse ECTEL authors, publications, network and knowledge. Finally, in Section 6, we conclude our work and discuss future directions.

2 Related Work

Every few years, research and contributions based on bibliometrics aspects emerge in specific communities. For example, in the field of digital libraries, Liu et al. [9] analyse

[1] http://www.ec-tel.eu/
[2] http://dblp.uni-trier.de/
[3] http://www.springerlink.com/

the contents from the Joint Conference on Digital Libraries community. Similar to our work, they expose several interesting facts of the DL community and an additional model to rank influential authors (AuthorRank).

In the field of Human Computer Interaction (HCI), Henry et al. [6] provide an analysis based on 4 major conferences in the field. The paper provides several visualizations that help readers to understand the characteristics of the HCI network, however, it does not provide an in-depth analysis or any interactive interface.

ACM Hypertext conference series also had its own analysis published by Chaomei Chen and Les Carr [1]. There, the authors present citations and co-authorship analysis from nine conferences over ten years. Their findings show that almost half of the papers refer to papers from the same series, which points to a very homogeneous research community.

Coming to the TEL field, Ochoa et al. [14] provided a co-authorship and citation analysis focused on TEL publications presented at EDMedia conferences. Similar research was also performed by Fisichella et al. [4] on top of partial data from EDMedia and ECTEL conferences. Their results provide interesting insights regarding collaboration networks in the TEL area and support the importance of co-author analysis and citation analysis for understanding, as well as analyzing scientific communities.

More recently, active members of ECTEL community have published interesting analysis on TEL bibliometrics. Reinhardt et al. [15] provided a brief authorship, co-authorship and citation analysis based on the first five years of ECTEL. With a slightly different approach, Derntl and Klamma [2] presented a thorough social network analysis on European TEL projects. Although focused on data from projects, their report is extremely relevant for the TEL research community. In fact, as we show in Section 3, TEL projects play a major role in supporting research.

Although plenty of research has been done on analyzing characteristics of conferences, authorship, co-authorship and citations, only a few provide up to date data that can be accessible by researchers. Thus, the main differential of our work is that, we not only provide an up to date analysis of eight years of ECTEL conference, but we also provide usable tools that allow researchers to explore the data, supporting the related work finding and possibly leveraging collaboration. Additionally, we provide enriched annotated data, an individual analysis of *technology* versus *learning*, and expose the data to LOD cloud.

3 ECTEL Uncovered

The first step in our work consisted of collecting data regarding past events of ECTEL. The entire data collection process consists of several steps that help us to access different online repositories. In the first step, we build a reusable[4] crawler that downloads pages with the metadata available in the DBLP Computer Science Bibliography, in our case, the ECTEL content pages[5]. The crawler downloads and structures the information such as year, paper title, number of pages, authors and DOI (Digital Object Identifier) url.

[4] Our crawler can be applied to different conference venues.

[5] `http://www.informatik.uni-trier.de/~Ley/db/conf/ectel/index.html`

Table 1: General statistics of ECTEL over the years. (*unique persons)

Year	2006	2007	2008	2009	2010	2011	2012	2013	Total
Papers	76	46	52	85	67	50	65	92	533
Authors	247	155	171	281	276	214	265	387	1193*
Citations (Avg)	12.1	12.8	8.3	7.5	5.5	5.0	2.6	1.4	7.8
Committee Members	25	36	29	56	85	80	73	92	157*

In the second step, we crawl each paper's DOI URL hosted at the Digital Library of Springer. Each paper has its own page containing further metadata. From Springer we collected abstracts of the papers, authors keywords, authors' affiliations, and the entire paper in PDF format[6].

The third step consists of extracting the information within the PDFs files. To this end, we converted the files to text format and extracted their contents and the acknowledgements sections.

In the fourth step, we enrich the text of the papers with annotations of entities. To perform this task, we use the WikipediaMiner [12] tool, a Web annotation service that is responsible for identifying all mentions of entities that can be linked to Wikipedia articles. Basically, the WikipediaMiner algorithm consists of two phases. Firstly, it detects and disambiguates words in the text that represent links to Wikipedia. To disambiguate, WikipediaMiner relies on machine learning algorithms that take into consideration the context of the word. Next, based on the first phase, their algorithm creates links from the disambiguated words to Wikipedia articles. Only those words that are considered to be relevant for the entire document are linked to the corresponding articles. The goal of the whole process is to annotate a given document in the same way as a human would link a Wikipedia article.

As a result, we have ECTEL research papers annotated with entities. The goal of this annotation is to provide a relational knowledge base of the real content of each paper. In contrast to authors's given keywords, the annotations can precisely characterize the contents of a paper and the profile of an author.

As a next step, we searched and crawled Google Scholar[7] to find out the number of citations of each paper. Google Scholar provides a good approximation of numbers of citations, however, one should be careful when drawing strong conclusions based solely on these numbers - it has been proved that this information is susceptible to manipulation [10].

In a final additional step, we crawled the Webpages of each ECTEL conference (from the year 2006 until 2013) in order to download the information regarding program committee members. All collected data was organized and stored in a relational database.

The general statistics of the ECTEL conference are exposed in Table 1. Although the last edition of ECTEL (2013) might be considered the most successful in number of papers and authors, we cannot observe a noteworthy growth over the years. However, program committee growth depicts how the community has expanded. We additionally

[6] Note that PDFs are not freely available.

[7] `http://scholar.google.com/`

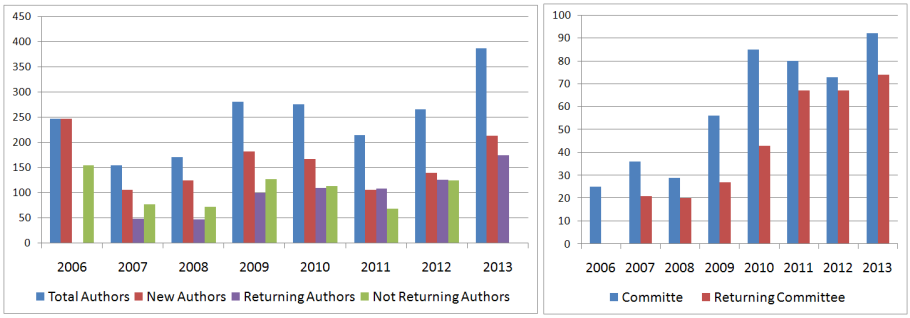

Fig. 1: On the left, the number of authors each year of ECTEL. *New Authors* represent authors that never published in ECTEL before. *Returning Authors* represent authors that have at least one publication in a previous year. *Not Returning Authors* represent authors that published only in that give year. On the right, the committee members numbers for each year of ECTEL. *Returning Committee* are the members who have been in part of the committee in a previous year.

structured the acknowledgment sections of each paper. In total, 48% of all papers have an acknowledgment section, 26% of them mention projects support and 20% explicitly mention European Commission support.

3.1 Community Growth

The establishment and growth of the ECTEL community is better depicted in Figure 1. We see the increasing number of *Returning Authors* and *Returning Committee*, meaning that each year the community welcomes more and new researchers. However, this growth is in fact smoother than it seems. The distribution of papers and authors follows a power law distribution where 833 authors (69.8%) have only one publication in ECTEL. Out of these 833 authors, 239 (29%) are listed as first authors in their papers.

In Figure 2, we plot controversial yet interesting results. The Figure draws together the number of accepted papers for each year, together with the number of program committee members and the number of papers that had at least one program committee member as author. In average, 49% of program committee members have papers accepted at the conference in the same year (varying from 36% up to 64%). Their papers consist of around 38% of all papers accepted over the years. In fact, the highest numbers were observed in the last edition of ECTEL (2013), where 53% of all papers belonged to at least one of the program committee members.

On one hand, these numbers raise a flag showing that the community is isolating itself. On the other hand, it shows the strength, unity and homogeneity of the TEL research community, aligned with findings from Chaomei Chen and Les Carr [1] on the internal citations on ACM Hypertext conference series. Those who are considered experts in the field (committee members) are constantly contributing to the progress of knowledge on TEL.

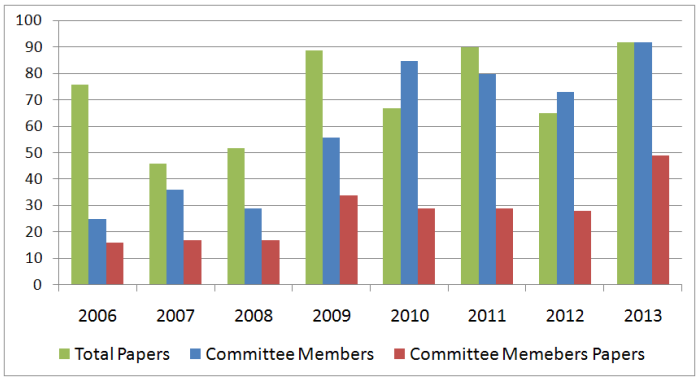

Fig. 2: Total number of ECTEL papers, committee members and papers from committee members over the years.

3.2 Topic Evolution

In order to understand the main themes discussed in ECTEL and the shift in topics over the years, in Figure 3, we see the tag clouds of authors' keywords choice for their papers. We see that, in the beginning (2006 and 2007), the conference had several publications on learning resources (*learning objects*) and information extraction (*metadata*). Later, in 2008 we see the rise of information management (*ontologies* and *knowledge management*). *Informal learning* was a popular topic during 2009 and 2010 venues, later giving way to *self-regulated learning*. The topic *mobile learning* first appears in 2008 without great impact, however it comes into the spotlight in 2010, maintaining its significance till date.

We also identify the appearance of *social media* in 2011, however, the topic did not catch up in the community. On the other hand, *serious games* established itself as a popular topic in the past two years. Finally, we see that *learning analytics* became, the most discussed theme in the last edition of ECTEL out of the blue. We believe that this was caused by the emergence of another venue in 2011, the International Conference on Learning Analytics and Knowledge (LAK). This venue is mainly organized by the same key persons of ECTEL and it is a natural trend that popular topics of discussion might migrate from one venue to another. However, the analysis of LAK conference is out of the scope of this paper.

3.3 Technology versus Learning

In this paper, we are also interested in understanding the individual evolution of the fields of technology and learning, and how they have blended together over the years. To this end, we manually annotated 1,197 keywords assigning a value to each one, whether it is a technology related term, a learning related term, or a neutral one. Each term was evaluated by three annotators, and the final annotation was decided by majority voting. In case of conflict where each annotator assigned a different value, the term was considered neutral.

(a) 2006 (b) 2007 (c) 2008 (d) 2009

(e) 2010 (f) 2011 (g) 2012 (h) 2013

Fig. 3: Tag clouds of papers' keywords (given by the authors) over the years.

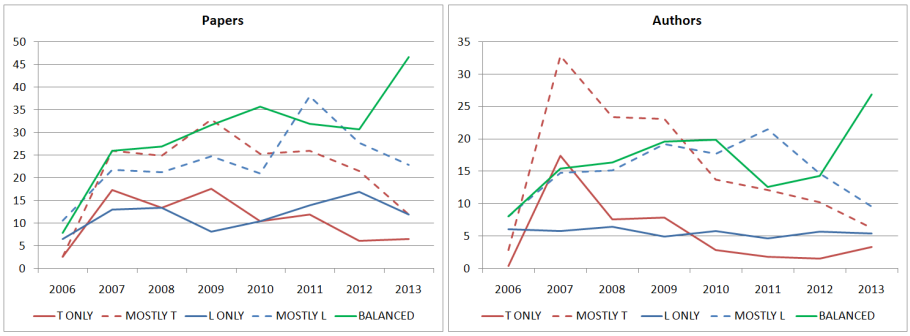

Fig. 4: The percentage of papers (on the left) and authors (on the right) pertaining to the fields of mostly or exclusively to the fields technology or learning, and balanced ones. *T ONLY* means papers/authors that have only technological keywords associated. *MOSTLY T* represents papers/authors that have 2 or more technological keywords than learning keywords. *L ONLY* means papers/authors that have only learning related keywords associated. *MOSTLY L* represents papers/authors that have 2 or more learning related keywords than technological keywords. Finally, *BALANCED* are papers/authors that have the approximately same amount (equal or ±1) number of technological and learning related keywords associated.

For example, terms such as *metadata*, *ontologies*, *web services*, *semantic web*, among others, have clear technological characteristics. On the other hand, terms such as *Orchestration*, *autism*, *reflective learning*, *phenomenography*, etc., provide a stronger association with the *learning* field. A few examples of keywords classified as *neutral* are *infrastructure*, *feedback*, *survey*, *TEL*.

We found out that each paper has in average 4.6 given keywords. Figure 4 shows the evolution of each field (technology versus learning) over the years in ECTEL. In terms of papers, we see that *exclusive* and *mostly learning* related research had significant growth in 2011 and in 2012. On the other hand, authors who were *exclusively* or

Fig. 5: Tag cloud of the annotations

mostly on the field of technology are slowly disappearing, or integrating their knowledge into the educational field. The rather constant increase of *BALANCED* papers and authors (those who have a fine equilibrium between technological and learning related keywords) depicts the accomplishment of ECTEL in bringing together both fields. The number of papers and authors that unify both fields has never been as high as in the last edition (2013) of ECTEL.

3.4 Annotations

The annotation process with Wikipedia Miner resulted in a total of 171,281 annotations. We identified 24,004 unique terms with an average of 321 terms per research paper. The tag cloud in Figure 5 depicts the top discussed topics in ECTEL research papers. The main difference between this tag cloud and the ones presented in Figure 3 is that the annotations are based on the whole content of the papers. It better represents what lies inside each research paper, rather than keywords chosen by the authors. Based on these annotations we are able to build a connected knowledge graph which will allow us to browse and explore the knowledge provided by papers and authors (see Section 5). Additionally, this data will be used in Section 4 for the prediction tasks.

4 Forecasting ECTEL

In this work, we are also interested in discovering whether it is possible to predict future characteristics of ECTEL conferences based on historical data. To tackle this, we chose two distinct experimental tasks: (i) predicting new community members and (ii) predicting future conference hot topics. Among the many possible predicting tasks, we consider these to be of greater interest for the community. The experiments presented in the remainder of this section were performed using the machine learning framework WEKA [5] and its implementation of Naive Bayes classifier.

4.1 New Community Members

For the first task, we are interested in investigating if a given author will, at some point in the future, *return* to the conference, i.e. will have another publication in a future edition of the ECTEL. Although debatable, we assume that a person who has published more than once (in different years) at ECTEL, has joined the community. In this light, we name this task *predicting new community members*.

For each author's first appearance, we arranged the data in order to aggregate past evidence that might help us predict his/her return. The data consists of pin-point information of the authors' first appearance, e.g. type of paper (short/full), authors' order, keywords, annotations, presence in the program committee and co-authors. Although we are considering the first appearance of a given author, his/her co-authors might have participated in ECTEL in previous editions. Therefore, to a given user profile we also consider if his/her co-authors had papers before, how many and if they were members of the program committee.

With this set of features, we were able to predict new community members with an accuracy of 81.9% (precision=0.826, recall=0.819 and f-measure=0.79). Surprisingly, the only features that have a significant weight in the decision process are *paper_type* and *was_pc_member*. These results mean that an author of a full paper has a higher probability of returning to the conference in a following year. The same applies for an author that is member of the program committee. Besides these features, the experiments detected several co-authors that have worked with returning authors. Examples of the top classified co-authors are Yannis A. Dimitriadis, Gonzalo Parra and Erica Melis.

4.2 Predicting Hot Topics

Our second chosen task consists of discovering which historical data are the most prominent for predicting future *hot topics* (papers' keywords chosen by the authors). For example, as we have seen in Figure 3, *personalization* and *informal learning* were hot topics in the 2009. Lately, in the year 2013, *learning analytics* and *mobile learning* became hot topics. Thus, the question raised is if it is possible to identify which past evidence leads to the rise of such topics. For example, if particular authors influence research trends.

For each appearance of a keyword in a particular year, we aggregate the information of this keyword pertained to the three previous years. Given that *learning analytics* is a hot topics in 2013, we investigate the information related to this topic from the years 2010, 2011 and 2012.

In this experiment, we were able to predict *hot topics* with an accuracy of 91.8% (precision=0.974, recall=0.918 and f-measure=0.941). Table 2 depicts the top influential features. We found out that the number of authors that chose a given topic two years in the past is the topmost influential feature, followed by the number of co-occurring topics in the previous two years. It is interesting to see that features regarding two years in the past have a higher impact than features extracted from a single year before. This means that topics that emerge in a given year, take another two years to become a *hot topic*.

Additionally, we observed that facts regarding a given topic that are older than two years do not provide useful information for predicting a *hot topic*. Finally, the experiments also output several authors who are ahead in time. These authors have published works of a given topic before it became popular. Marcus Specht, Nicole C. Krämer, Davinia Hernández Leo and Günter Beham amongst others might be considered visionaries in the ECTEL community.

Table 2: Top features for predicting new ECTEL hot topics.

Rank	Feature Name (years before)	Weight
1	# of authors (-2)	0.04077
2	# co-occurent Keywords (-1)	0.03652
3	# co-occurent Keywords (-2)	0.03368
4	# of papers (-2)	0.03324
5	# of authors (-1)	0.02721
6	# of papers (-1)	0.02721

5 Exploring ECTEL

In order to expose our results and analysis to the community, we built several online interactive interfaces that enable users to browse the contents of ECTEL through different facets views.

We built all interactive graphic visualizations using D3 (Data-Driven Documents) JavaScript library [8]. The visualizations we present consist of bar charts, tag clouds, force-directed graph, and bubble charts among others. The interfaces provide information that is easy to digest regarding statistics of the conference, content of the papers and relationships between authors, papers and knowledge.

It provides easy access and navigation to all sections of the website, an easy to use and attractive interface and supportive help texts. Additionally, it was developed to be platform independent and to support any modern browser in any device.

While it is not hard to find relevant research using existing tools, there is little one can find beyond explicitly specified authors and corresponding publications. The main contribution of our interfaces is the assistance to users, for discovering information, authors' network connections and relevant related work.

The Website is divided in four main categories: Authors, Collaboration, Keywords and Knowledge. *Authors* section provides the profile of each author in the ECTEL community. It lists information of the authors papers, the keywords usually associated to the author, annotations and the collaboration graph (see Figure 6). Additionally, it provides an overview of the author publication count in comparison to the rest of the community.

In the *Collaborations* section, one is able to clearly identify all co-authoring relations of a given researcher, or simply browse through the whole co-authoring graph (see Figure 7).

[8] `http://d3js.org/`

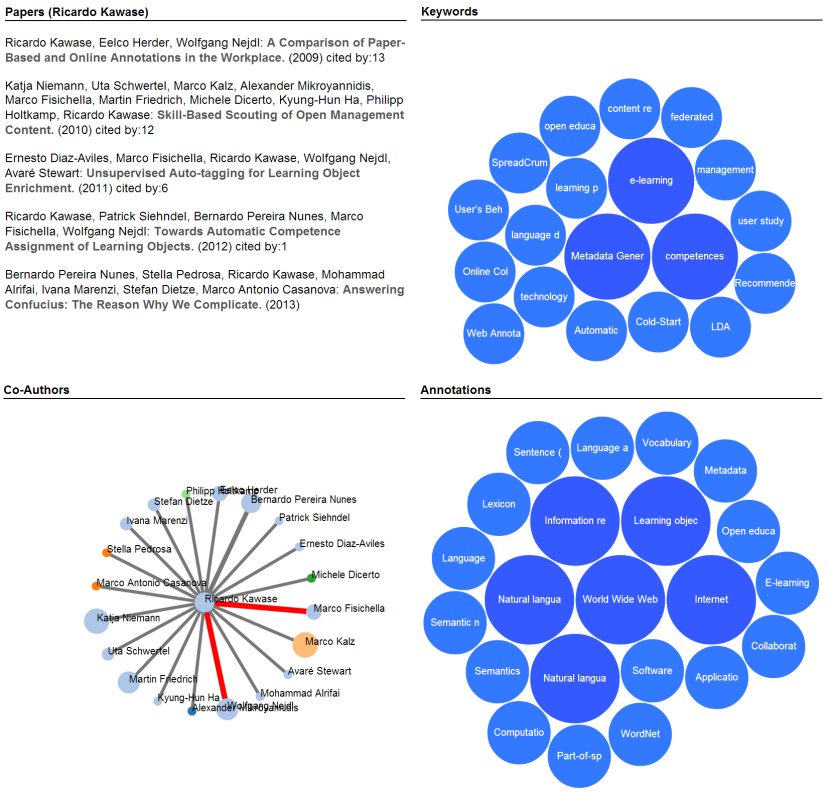

Fig. 6: Authors profile interface containing list of papers, keywords, annotations and collaborations.

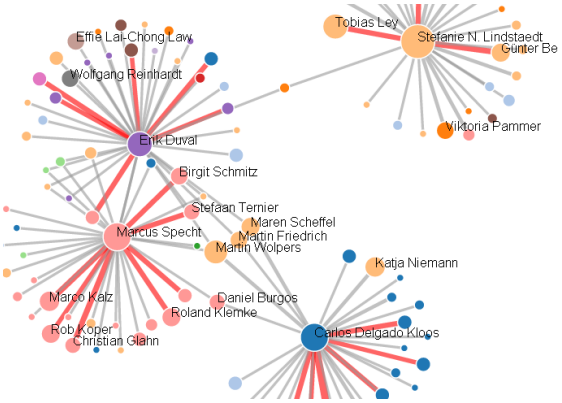

Fig. 7: Iteractive collaboration graph.

In the *Keywords* section, the user can identify which are the most trending topics of a conference and the most influential researchers in those topics. The interface further helps to track evolution in the research fields, by leveraging year-based filters to help users in identifying the transition and development of knowledge and authors along the years (see Figure 8). Both authors' keywords and annotations are provided in this section.

The section *Knowledge* provides similar interfaces as the section *Collaboration*, however, the connections are based on keywords/annotation co-occurrence. This section provides great exploratory features for finding relevant related work and experts on each field of knowledge. All the interfaces provide interactive commands that trigger browsing, exploration and filters.

We invite the reader to try our online prototype [9].

5.1 ECTEL in the LOD Cloud

By bringing the underlying complex relations (between authors, research collaborations and conferences) to the surface, we greatly improve the user experience while immediately satisfying one's information need. As an additional contribution, we expose this enriched knowledge as Linked Data (by following the principles of publishing such data) that can be queried at the SPARQL endpoint[10]. We also provide for a Pubby[11] interface to facilitate additional exploration of the knowledge base. The interface can be accessed at `http://meco.l3s.uni-hannover.de:8899/dblpXplorer/`. By exposing this knowledge to the Linked Open Data Cloud, we promote re-use of the structured data.

6 Conclusion

In this paper, we presented a thorough data analysis on top of the past eight years of ECTEL. First, we described, step by step, the data crawling and enrichment process. It is important to emphasize that your crawling steps presented in Section 3 are easily reusable, thus enabling us to build similar knowledge over difference conference venues.

Based on the collected data, we uncovered interesting facts of the TEL community regarding community growth, topics evolution in the conference and a breakdown comparison between technology and learning. Additionally, we performed two experiments in order to demonstrate that the historical data of ECTEL can be used for predicting upcoming facts with relatively high accuracy.

In fact, our main contribution lies in the exposure of the collected data back to the community. Our interactive user interfaces allow researchers and the general interested public to browse through the available and enriched data past venues of ECTEL. Our user interfaces leverage the finding of related work, experts on different topics, and most

[9] `http://www.l3s.de/~kawase/DBLPXplorer/ECTEL/`

[10] `http://meco.l3s.uni-hannover.de:8829/sparql?default-graph-uri=http://purl.org/dblpXplorer/`

[11] `http://wifo5-03.informatik.uni-mannheim.de/pubby/`

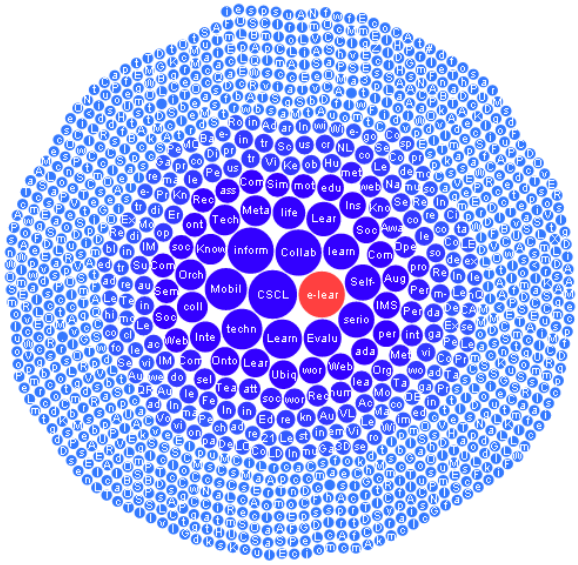

Fig. 8: Iteractive keywords bubbles interface.

importantly, might augment collaborations. Additionally, the exposure of the collected data to the linked open data cloud allows third-part applications to reuse our work.

Although we identify our work as a contribution to the community, it indirectly contributes to improvement of research in the TEL field. As future work, we plan to conduct a user evaluation of our proposed interfaces in order to collect feedback. Based on the given feedback we plan to improve the interfaces and to build new means for browsing the data.

7 Acknowledgement

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