Brief Communication

Interoperability and Information Integration in an Early Online Academic Digital Library of Theses and Dissertations: The Case of BTD

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ABSTRACT

Cooperative organization has been proposed as a means to improve the usefulness of virtual libraries. Information interchange among library and other academic applications is often hindered by the lack of application interoperability. This hindrance may be overcome through the development of standards that allow for digital libraries to exchange and share information with other applications. The Graduate Program in Production Engineering (PPGEP) of the Federal University of Santa Catarina (UFSC) launched its Theses and Dissertations Bank (BTD) in 1995. BTD is possibly the first online academic digital library of theses. From a digital document repository, BTD evolved into a system that combines bibliometry and informetry features. BTD is used by students and faculty in their research activities, but also by decision makers from industry and academia. They use it, respectively, to search for specialists and to measure interest and knowledge interchange among PPGEP research areas. This article presents the history, features, and development prospects for the BTD project. The integration of BTD with other academic applications, especially those of the Brazilian national science and technology platform, is emphasized.

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INTRODUCTION

Mason et al.[1] suggest the increment of cooperative organization and the combination of efforts as directions for the development of virtual libraries. The technological approach for the achievement of these authors' proposition might be the interoperability of several applications or the collaboration over a unified, agreed-upon tool.

An important issue in the development of collaborative environments is the consideration of interests and needs of all stakeholders involved. Virtual library projects should take into account not only librarians' and readers' requirements, but also the interests of decision makers at several levels. While the first are interested primarily in the collection items themselves, the latter are interested in bibliometric and informetric indicators, in patterns of interaction among authors, and in the identification of experts for the solution of specific problems.

In the graduate school setting, a digital library should be useful not only to students and advisors, but also to managers of the knowledge development process. They are area coordinators, graduate school managers, deans, research group leaders, and others. They are interested, for instance, in the measurement of access frequencies ordered by subject, keyword, advisor, thesis (doctoral level) or dissertation (masters level), and publication year. This kind of information is important in their decision-making process.

The Theses and Dissertations Bank (BTD) of the Graduate Program in Production Engineering (PPGEP) of the Federal University of Santa Catarina (UFSC), Brazil, was conceived taking these considerations into account. Since its first release, in 1995, about 3000 theses and dissertations approved at PPGEP since 1970 have been made available, more than 1000 in full text. The second version went online in December of 2000,[2] recently reaching 100,000 hits, after one year and a half. Several options for access statistics are offered in addition to access to content and catalog information. These statistics have been used by PPGEP managers in their decision-making process.

This paper reports the development, use, and future of the BTD. Public funding of university digital libraries is pondered, together with an account of information requirements of various stakeholders. BTD's starting points,

[1]Mason, J., Mitchell, S., Mooney, M., Reasoner, L. & Rodriguez, C. (2000) Infomine: Promising directions in virtual library development. *First Monday*, **5**(6). Retrieved May 31, 2002, from http://first-monday.org/issues/issue5_6/mason/index.html.

[2]UFSC/PPGEP (2000) Banco de Teses e Dissertações do PPGEP. Florianópolis-SC, Brazil: Programa de Pós-Graduação em Engenharia de Produção, Universidade Federal de Santa Catarina. Released in December, 2000. Retrieved June 21, 2002, from http://teses.eps.ufsc.br/.

features, and achievements are described. Current and future developments are discussed. The integration of BTD with other academic applications is discussed, especially with those belonging to the Lattes Platform[3]—the Brazilian national platform of science and technology information systems, and web portals.

PUBLIC FUNDING FOR A UNIVERSITY DIGITAL LIBRARY: WHAT'S THE PAYBACK?

Academic workforce qualification depends on public funding to a large extent anywhere in the world. In Brazil, where this work is conducted, the private sector hardly invests in human resources at the academic level. Investment of the scarce public funds must be done wisely.

The payback or result of this investment is hard to measure precisely — the wealth generated is mainly in the graduates' minds. However, theses and dissertations, and the interest they generate, are concrete results that *can* be measured.

Recently Lawrence[4] demonstrated that articles that are available online are more cited than those that aren't. The availability of academic works in digital libraries benefits researchers. This benefit, however, depends on the level of availability and ease of access. Well-equipped and content-rich digital libraries reach their full potential only if they offer access at affordable rates.

Offering good digital libraries is a strategy for the improvement of graduate students' productivity. They offer ubiquity, flexibility, and advanced search facilities in a way that traditional libraries can't offer. This is an important investment of public funds, in addition to scholarships and funding for projects. It seems advisable, therefore, to make public (or give back to the taxpayers) the results of their investment — for instance, offering free access to the theses and dissertations produced.

Baggio[5] states that if the accumulated knowledge is not shared with the society, the abyss that separates rich and poor is deepened. By offering its production to the public through a well-equipped digital library, Brazilian graduate programs take the opportunity to expose their quality and to promote their integration with industry and with society in general. The next section reports the history of BTD,

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[3]CNPq (2002b) Plataforma Lattes. Brazilian National Research Council (CNPq). Retrieved June 2l, 2002, from http://lattes.cnpq.br/.

[4]Lawrence, S. (200lb) Online or invisible? *Nature*, **411** (6837), 52l.

[5]Baggio, R. (2000) A sociedade da informação e a infoexclusão. *Ciência da Informação*, **29**(2), 16–21.

a free digital library and information system maintained by a public
university.

The Evolution of BTD

This section describes BTD's 7-year history (1995–2002). The building of the
Brazilian chemical engineering theses and dissertations bank in 1999 repre-
sented a major technological influence because it integrated aspects of in-
formation integration between an accreditation agency and the digital
library. The BTD, version 2001, introduced new services in an online imple-
mentation.

Beginning

The PPGEP strategic planning established in 1985 a ten-year goal: the or-
ganization of a distance education program that should allow students to
access content without geographic restrictions, based on information tech-
nology and telecommunications. In July, 1995, PPGEP's Distance Educa-
tion Laboratory (LED) installed its videoconference infrastructure to be
used in a masters program offered in partnership with other universities
in Santa Catarina state (with support from Funcitec, a state foundation
for science and technology, and from CAPES, the Coordination for the Im-
provement of Academic Personnel — a federal funding and accreditation
agency).

The need for digital libraries and integration of academic and adminis-
trative platforms was recognized since LED's inception. BTD was imple-
mented also in 1995, roughly a year after the appearance of Netscape®
and Mosaic®. The available Internet infrastructure initially used a 64 kbps
link. An agreement between PPGEP and the state government allowed for
an increment to 2 Mbps.

A team was formed at the Stela Group (a development laboratory at
PPGEP) to produce HTML versions of theses and dissertations, usually
delivered as .doc files (particularly text editors such as Word® and StarOf-
fice®). The first dissertation was published in digital form on May 11th,
1996:

> http://www.eps.ufsc.br/disserta/palomino/indice/index.html
> -rwxr-xr-x 1 www 21957 May 11 1996 index.htm
> -rwxr-xr-x 1 www 21957 May 11 1996 index.html

Up to the time this article was written, we couldn't find any record of an
earlier online academic digital library of theses and dissertations. An addi-
tional 357 works were uploaded to BTD until 1999. By that time several
theses and dissertation libraries had gone online, such as the ones by the

Massachusetts Institute of Technology[6], ProQuest[7], Virginia Tech[8], and IBICT[9].

BTD was created to give transparency to LED's (and PPGEP's as a whole) production of theses and dissertations. LED's initiatives and activities have inspired universities throughout the country.[10]

The Chemical Engineering Bank

The Stela Group also developed, in 1999, the first Brazilian national data bank of theses and dissertations in chemical engineering. This bank allows for the capture of data and metadata about theses and dissertations.

The capability of dealing with content, catalog, and metadata is consistent with the requirements of CAPES, providing for information transference for graduate program accreditation. This approach to information interchange in the chemical engineering bank set the foundation for the current BTD implementation.

BTD Version 2001

The theses and dissertations data bank was integrated with the PPGEP academic management platform. The files with the theses and dissertations and their records in the platform were linked. A BTD website was designed, going online by the end of November of 2000.

Most BTD users are students and faculty. However, since BTD is free and available over the web, it has been useful to strengthen PPGEP's connection with industry. BTD has received about 23,000 hits in its first 6 months online, about 60,000 within a year, completing 100,000 in June of 2002, after 18 months in service.

BTD has the records of all theses and dissertations defended at PPGEP since its creation in 1970. There are more than 3000 works with the following distribution by mid-2002: 74% masters dissertations, 13% doctoral theses, 13% qualifying monographs. More than 1000 works are available as full text, in HTML or PDF. The access count for the most accessed thesis is about 2300, and the website hit counter is about 120,000 (in August of

[6]MIT (2002) Digital library of MIT theses. Retrieved May 3, 2002, from http://theses.mit.edu/.

[7]UMI (2002) ProQuest digital dissertations. Retrieved June 21, 2002, from http://wwwlib.umi.com/dissertations/.

[8]Virginia Tech (2002) Digital library and archives. Retrieved May 3, 2002, from http://scholar.lib.vt.edu/theses/.

[9]IBICT (Brazilian Institute for Information on Science and Technology) (2002) Biblioteca Digital Brasileira. Retrieved June 21, 2002, from http://www.ibict.br/bdb/inicio.htm.

[10]Wahrhaftig, R., Ferraza, A.M. & Raupp, M. (2001) Portas Abertas para a Educação Superior. Universidade Eletrônica do Paraná.

FIGURE 1. The BTD website (UFSC/PPGEP 2000).

2002). Fig. 1 shows the website interface. The next section describes the features of BTD that allowed for such expressive numbers.

BTD'S FEATURES

The BTD website is available in Portuguese, organized in six resource areas: general information, recent and coming defenses, access to theses and dissertations, BTD statistics, related links, and access rankings. The features of these resources are detailed next.

General Information
This section describes the objectives of BTD and presents its information sources. The main features are briefly commented upon, together with some historical background on the digitization process undertaken by PPGEP's Media and Knowledge Lab (LMC) from 1995 to 1999. From 2000 on, PPGEP requests students to furnish digital copies in popular formats, to be translated into Adobe®'s portable document format (PDF).

Recent and Coming Defenses
This section of the website reports the scheduling of defenses to occur shortly and lists defenses occurring in the last four months. It allows interested parties to search defenses by area or graduate level (doctoral theses

and qualifying monographs, masters — dissertations) and to contact authors, advisors, and internal (PPGEPs) committee members. It is possible, from each defense record, to find statistics about the advisor, and to access his advisees' theses and dissertations, which also can be done through the specific "Theses and dissertations" link, as described next.

Access to Theses and Dissertations
This is the most popular section of the website. It allows for searching theses and dissertations with search filters: By title (complete or incomplete), keywords, author, advisor, committee member, advising tutor (a doctoral student who co-advises a masters candidate), program area, year, and level (masters, qualifying, or doctorate). Filters can be combined.

The theses and dissertations are available in Portuguese. Although there are a few theses written in English, this possibility was dropped in order to comply with a recent UFSC policy that made Portuguese the mandatory language for theses and dissertations.

For each record, it is possible to see the hit counting, and to access the advisor's curriculum and statistics of defenses with counting by year and average completion time. The advisor's curriculum is in the Lattes Platform (CNPq 2002b).

The steps to access each thesis or dissertation are:

1. Search configuration — instantiate terms and criteria for the search.
2. Results — read the match list.
3. Choice — click on the thesis or dissertation link.
4. Access — read the record and access (where available) the full content.

Theses and dissertations are accessed mainly by academic users, but also by the community at large. A search for "freight centers", for instance, points to six monographs defended between 1993 and 1998. This search allowed PPGEP to demonstrate, online and in real time, its documented know-how in the subject. The demonstration was made during a visit from the president of a telecommunications company who was interested in academic works related to freight center customer service. This illustrates the role in knowledge management played by BTD.

BTD Statistics
This link was designed to assist decision makers and researchers who are interested in measurements of PPGEP's production of theses and dissertations. Fig. 2 illustrates one of the statistic tables that can be obtained: mean completion time for graduates, in months, according to each program area, type of degree, and program category (presence, distance, or off-campus program).

2. TEMPO MÉDIO NO CURSO (em meses)

2.1. Tempo Médio no Curso por Área de Concentração

Área de Concentração	Mestrado			Qu...
	Presencial	Presencial Virtual	Fora de Sede	Do...
Empreendedorismo	20	-	-	
Engenharia de Avaliação e de Inovação Tecnológica	33	23	24	
Engenharia de Produção	40	-	-	
Ergonomia	30	22	24	
Gestão Ambiental	26	22	-	

FIGURE 2.   BTD's statistics (UFSC/PPGEP 2000).

The section displays general statistics on number of defenses, number of full text works, and mean time for completion according to a variety of parameters: area, type of degree, program category, and year of defense. It is also possible to custom-fit statistics using filters for program area, advisor, entry year, and graduation year.

The generation of statistics is an important contribution of BTD to graduate education management. The detection of a tendency to reduce mean completion time and, especially, the comparison of mean completion times among the three categories of masters programs (on-campus, distance, and off-campus) allow for an appraisal of the results of advising efforts.

The distance (videoconference) masters program shows the smallest mean completion time among the three categories. Ongoing studies try to assess the reasons for this. It is speculated that two main factors influence the shortest completion time for the distance program: the identity of candidates and topics (usually focused on their companies' problems), and the advising system (in which advisors and tutors teamwork to keep candidates on track). Tutors are doctoral students who work in association with junior and senior advisors.

Related Links
Related links lead the user to other digital libraries, as well as to articles and news. News and articles are presently Portuguese-only. Digital libraries linked include IBICT (2002), MIT (2002), Virginia Tech (2002), ProQuest (UMI 2002), Physics at Unicamp,[11] and DiTeD[12].

[11]IFGW (2002) *Teses Digitais — Instituto de Física Gleb Wataghin*. Unicamp (State University of Campinas-SP, Brazil). Retrieved June 21, 2002, from http://www.ifi.unicamp.br/ccjdr/teses/.

[12]DiTeD (2002) Dissertações e Teses Digitais. Biblioteca Nacional, Portugal. Retrieved June 21, 2002, from http://dited.bn.pt/.

This section of the website also offers documents and information for the candidates on the bureaucratic aspects of graduation. In addition, the Brazilian copyright law[13] is presented.

Access Rankings
This section displays access rankings by author, advisor, and area. It is one of the advanced features of BTD, created to allow for the measurement of interest levels.

The ranking by author shows the 100 most accessed works. The ranking by advisor positions them according to the average hit counter for their advisees' available works. It also links each advisor with his curriculum vitae on the Lattes Platform (CNPq 2002b) and statistics. The ranking by area simply ranks program areas according to the number of hits.

FUTURE DEVELOPMENT

BTD has already made an impact on how PPGEP's candidates conduct research, and on the visibility of graduate monographs. The hit counting suggests the vigor of the introduction of new technologies and their effect on researchers' working styles. The statistics and rankings endow the system with valuable tools for decision support.

New developments are planned for BTD, especially regarding scientific journalism and knowledge management. BTD is planned to offer interviews with graduates and their advisors and committee, and alumni track-keeping — forming a talent bank, aiming at the interaction with alumni and the organizations they are associated with.

The next developments also include the verification of methodology of submitted theses and dissertations, advanced search features (full text), the building of informetric indexes, an organizational knowledge management module (dealing with the building of a profile of each advisor's areas of interest and frequent topics), artificial intelligence tools in theses and dissertations auditing (for instance, for detecting plagiarism), and the application of intelligent auditing systems for content comparison. Both methodology verification and the application of intelligent auditing systems are current research topics at PPGEP.

This suite of functionalities, once implemented, tends to accelerate the pace of change that is just beginning in the academic setting. The university is changing, with evident impact on libraries. However, we consider that

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[13]MCT (1998) *Lei No 9.610, de 19 de Fevereiro de 1998*. Diário Oficial da União. MCT (Ministry of Science and Technology), Brasília-DF, Brazil. Retrieved June 21, 2002, from http://www.mct.gov.br/legis/leis/9610_98.htm.

the achievements are few if we think of the potential of technology usage in libraries. Digital libraries still stumble on inadequate information and software integration. Private information providers offer solutions that are too difficult to integrate with the rest of the library environment.

The integration of digital libraries depends on the building of standards that allow for the interchange of information and interoperability of applications. Caplan[14] observes that the development of standards for digital libraries is hard because of the lack of leadership for a collaboration effort.

Improvements in access to scientific literature have already changed the entire scientific process.[15] Bollacker *et al.*[16] maintain that automatic tools to support research will be increasingly important in the future. Nonetheless, there is still much to advance in the development of digital libraries.

Cameron[17] and Brüggemann-Klein *et al.*[18], propose that authors submit, together with their papers, an annotated bibliography for database insertion, therefore making it easy to access catalog information on articles. This is only one example of action that requires general collaboration for its implementation. The implications of such actions, however, can have a great impact on digital libraries. The next section describes standardization efforts that are underway in Brazil, with potential benefits for digital libraries.

STANDARDIZATION EFFORTS IN THE LATTES PLATFORM AND POTENTIAL BENEFIT FOR BTD

Lattes, named after a renowned Brazilian physicist, is the Brazilian platform of science and technology information systems and web portals (CNPq 2002b). The most widely known application, Curriculum Lattes, is used by individual researchers to generate their curricula. Each researcher then submits his curriculum to the Brazilian National Research Council

[14]Caplan, P. (2000) Oh what a tangled web we weave: Opportunities and challenges for standards development in the digital library arena. *First Monday*, **5**(6). Retrieved May 3l, 2002, from http://firstmonday.org/issues/issue5_6/caplan/index.html.

[15]Lawrence, S. (200la) Access to scientific literature. In Butler D. (Ed.) *the nature yearbook of science and technology*. London, England: Macmillan, pp. 86–88.

[16]Bollacker, K.D., Lawrence, S. & Giles, C.L. (2000) Discovering relevant scientific literature on the web. IEEE Intelligent Systems **15**(2), 42–47.

[17]Cameron, R. D. (1997) A universal citation database as a catalyst for reform in scholarly communication. *First Monday*, **2**(4). Retrieved May 3l, 2002, from http://firstmonday.org/issues/ issue2 4/cameron/index.html.

[18]Brüggemann-Klein, A.Klein, R. & Landgraf, B. (1997) BibRelEx: exploring bibliographic databases by visualization of annotated contents-based relations. Retrieved May 3l, 2002, from http://citeseer.nj.nec.com/352222.html.

(CNPq) in order to qualify for scholarships, to be accounted for in accreditation cycles, etc.

The Platform currently keeps about 230,000 curricula. The Lattes Platform website counts about 1.3 million hits in the last 11 months (September of 2001 to August of 2002). Since CNPq is the most important Brazilian funding agency, and most benefits for researchers depend on the availability of their Lattes curriculum, it is believed that the Platform has a very comprehensive coverage of Brazilian researchers.

The Stela Group is the developer of both BTD and the Lattes Platform. The multilingual curriculum and the Lattes Platform Markup Language[19] are development initiatives at the Stela Group that deal with systems integration, with potential impact on the BTD.

The Lattes Platform Markup Language

Considering collaboration efforts for system integration, Brazil offers as an example the LMPL (CNPq 2002a), the Lattes Platform Markup Language. It is an XML-based ontology designed to allow for the integration of science and technology information systems. LMPL allows for the building of dynamic links among institutional portals—for instance, linking a thesis in a theses portal and its author's curriculum in a funding agency's portal, thus reinforcing the character of public access and transparency.

LMPL has been developed by a team from several Brazilian universities and agencies. It started by curricular information, but extensions focused on bibliographic information are possible in the near future.

A similar collaboration in the digital library arena is advisable. A recent initiative led by the Brazilian Institute for Information on Science and Technology (IBICT) works on a national definition for theses and dissertations metadata, based on the Dublin Core metadata initiative.[20] Such a definition can be used as an instrument for harvesting mechanisms for theses and dissertations.

The Multilingual Curriculum for CvLAC

The Lattes Platform supporting technology is presently being applied to CvLAC[21], an initiative to integrate science and technology information systems of Portuguese- and Spanish-speaking countries.

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[19]CNPq (2002a) Comunidade LMPL — Linguagem de Marcação da Plataforma Lattes. Brazilian National Research Council (CNPq). Retrieved June 21, 2002, from http://www.stela.ufsc.br/lmpl/.

[20]DCMI (2002) Dublin core metadata initiative. Retrieved May 3, 2002, from http://www.dublincore.org/.

[21]De los Ríos, R., & Santana, P. H. A. (2001) El espacio virtual de intercambio de información sobre recursos humanos en Ciencia y Tecnología de América Latina y el Caribe: Del CV Lattes al CvLAC. *Ciência da Informação*, **30**(3), 42–47.

An initial difficulty for spreading application development throughout Spanish-speaking countries was the fact that the language for specification in the Lattes Platform is Portuguese. For Spanish-speaking developers to understand data models and other documents, they must be translated into Spanish, overcoming tricky problems such as false cognates.

An initial approach to this problem has been to build a translation system for XML curricular specifications, using the LMPL specification as a starting point. Fig. 3 presents a diagrammatic view of the process.

A translation specification defines source and target languages and a detailed translation of all tags in the curriculum markup from the source to the target language. This is shown in Fig. 4 (stylesheet) and 5 (dictionary).

Finally, Fig. 6 shows fragments of a researcher's curriculum with Portuguese (default) and English markups and would be Spanish in the context of CvLAC. This is an initial step that translates markup tags, thus facilitating the multilingual *development* of applications.

Further development initiatives should focus on the translation of *content*, a problem at a deeper level of difficulty. The potential for integration, however, is evident since developers who can only speak their native language can now implement solutions that have the potential of manipulating data from a wide range of sources.

FIGURE 3. Translation schema in the CvLAC Platform.

```
- <xsl:stylesheet version="1.0"

xmlns:xsl="http://www.w3.org/1999/XSL/Transform">

    <xsl:param name="dictionary-

name">dicionario.xml</xsl:param>

    <xsl:param name="translate-to-lang">en</xsl:param>

    <xsl:param name="translate-from-lang">pt</xsl:param>
```
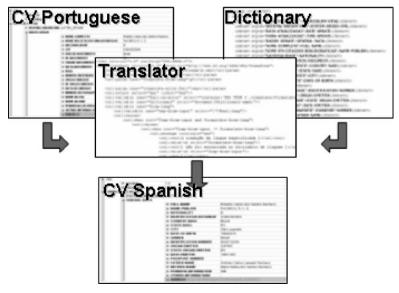
FIGURE 4. Translator specification document (fragment)

```
    <element original="DATA-ATUALIZACAO">DATE-

UPDATE</element>

    < element original="HORA-ATUALIZACAO">TIME-

UPDATE</element>

    < element original="DADOS-GERAIS">GENERAL-

DATA</element>

    < element original="NOME-COMPLETO">FULL-

NAME</element>

    < element original="NOME-EM-CITACOES-

BIBLIOGRAFICAS">NAME-PUBLISH</element>

    <element

original="NACIONALIDADE">NATIONALITY</element>
```

FIGURE 5. Dictionary specification to translate tags from Portuguese (into English in this example).

CONCLUDING REMARKS

This article presented the experience of PPGEP/UFSC in the building of its Theses and Dissertations Bank (BTD), emphasizing its character of

```
    <?xml version="1.0" encoding="ISO-8859-1" ?>
- <CURRICULO-VITAE SISTEMA-ORIGEM-
XML="LATTES_OFFLINE">
- <DADOS-GERAIS NOME-COMPLETO="Roberto Carlos dos
Santos Pacheco   " NOME-EM-CITACOES-
BIBLIOGRAFICAS="PACHECO , R. C. S." NACIONALIDADE="B"


    <?xml version="1.0" encoding="UTF-16" ?>
- <CURRICULUM-VITAE SYSTEM-ORIGIN-
XML="LATTES_OFFLINE">
- <GENERAL-DATA FULL-NAME="Roberto Carlos dos Santos
Pacheco" NAME-PUBLISH="PACHECO , R. C. S."
NATIONALITY="B"
```

FIGURE 6. Curriculum with markup for a researcher, with tags in Portuguese (above) and English (below).

transparency and knowledge management. The role of digital libraries in public universities was discussed. The history of BTD was reported, together with a description of its functions. The first dissertation went online over the web on May 11th 1996, what possibly makes BTD the first online library of its kind. Perspectives for future development were conjectured, especially with regard to the integration with applications in the Lattes Platform.

The technology and the methodology for the building of BTD have been part of the continued effort for building the Lattes Platform (CNPq 2002b). The Lattes Platform was conceived and operated to support funding, planning, and evaluation of science and technology. Several agencies have worked to integrate science and technology applications into the Lattes Platform, and BTD also has this aim.

The result of these efforts will be the standardization of metadata, allowing for the establishment of links among several institutional web portals. In the future, we expect to have access to theses, dissertations, and articles from within a researcher's curriculum, and from these to the author's curriculum, thus strengthening the character of transparency and public access to publicly-funded scientific production.

In terms of international trends, the Brazilian efforts are in tune with recent studies on the importance of information visibility (Lawrence 2001b). By making public the production of theses and dissertations, BTD and other Brazilian and international initiatives contribute to widening the accessibility to scientific sources, which is crucial for scientific development.

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