Jointly published by Kluwer Academic Publishers, Dordrecht and Akadémiai Kiadó, Budapest

Scientometrics, Vol. 48, No. 1 (2000) 45–64

Emphasis on validation in research: A meta-analysis

SANTOSH K. NANDA,[1] ARIEL L. RIVAS,[2] WILLIAM M. TROCHIM,[3] J. DAVID DESHLER[4]

[1]*National Academy of Agricultural Research Management, Hyderabad-500 030 (India)*
[2] *College of Veterinary Medicine, Cornell University, Ithaca, NY 14853 (USA)*
[3]*Department of Policy Analysis and Management, College of Agriculture and Life Sciences, Cornell University, Ithaca, NY 14853 (USA)*
[4]*Department of Education, College of Agriculture and Life Sciences, Cornell University, Ithaca, NY 14853 (USA)*

The emphasis of validity as a publication content was investigated in dissertations and journal articles. The time of first publication, longitudinal publication profile, ratio of articles to dissertations, and time lag between dissertations and articles emphasizing validity were compared within and among various fields. A three-decade gap separated the first field adopting validity-related contents in its dissertations from the latest fields that did so. The longitudinal data suggested three groups of fields (Agricultural Sciences, Applied Sciences and Social Sciences) which showed consistent differences among groups and consistent similarities within groups in their emphasis on validity-related content. Adoption of validity-related content in dissertations always preceded adoption of validity-related content in journal articles. On average, less than 4% of journal articles included validity-related content across fields. These findings support the hypothesis that validity has been introduced and disseminated within fields following patterns predicted by diffusion of innovations theory. It is argued that this pattern is inconsistent with an efficient and interdisciplinary utilization of available knowledge. Policy recommendations are made for developing strategic communication and education programs for academicians and journal reviewers.

Introduction

This study is based on the assumption that science is less scientific than expected in the sense that what may appear to be valid under the perspectives of one discipline or field may not be so if assessed under the perspectives of other disciplines or fields. Lack of interdisciplinary validity may then be a major constraint to solving complex problems (i.e., problems that may require interdisciplinary solutions). Overconfidence in knowledge provided by individual specialties has many times resulted in unanticipated problems. From environmental threats to public health risks, from economic disruptions

0138–9130/2000/US $ 15.00

to technological gaps, examples abound indicating the importance of interdisciplinary knowledge integration. Lack of interdisciplinary validity appears to be a major factor preventing knowledge synthesis.

Validity may mean different things to different people in different disciplines and contexts. It is difficult to define validity with reductionistic or quantitative formulas. Yet, a major attempt to address validity with operationalizable approaches has been contributed by *Cook* and *Campbell*.[1] They identified four major threats to validity (construct, internal, external, and statistical). Construct validity refers to how appropriate a simplified version (model) of a problem is so that we can actually solve the problem of interest. If there is adequate "construct validity" the theory goes, a modification of the model will actually modify the intangible problem. However, sometimes, even when the model or "construct" of the problem is appropriate, interventions may not lead to the expected results because there are unknown factors. In fact, most of the time we are not aware of the number and magnitude of unknown factors having influence on problems of our interest. These unknown factors are regarded as "internal" threats to the overall validity. Thus, even if we implement the adequate "solution" (i.e., our construct appears to be valid), it may not produce the expected results. This fact alone implies the need for interdisciplinary approaches to address complex problems since unknown "internal" factors are often known within other disciplines or fields. In addition, even when we have adequate "construct" and "internal" validity, it may happen that when we want to reproduce or generalize the application of our solution to new environments or groups it fails to yield the expected results. That may be the case when new environments or social groups differ in some characteristics from those where a solution has initially been observed. This is referred to as an "external" threat to validity. It is the typical case when seeds developed under a certain climate do not prosper when transferred to other climates; or when medical treatments studied in patients of certain age groups are administered to patients of other age groups; or when certain economic policies, successful in certain countries, are applied to different countries. Again, sometimes these unknown "external" validity threats might be known to other disciplines or fields. Without "construct," "internal," or "external" validity, no quantitative analysis ("statistical" validity) can improve the overall validity. Earlier studies pertaining to reporting pattern and adoption of validation concepts, though limited to single specialized subject fields, suggested that most of the research investigations fail to address validity threats.[2–5] Thus, interdisciplinary approaches perhaps, by themselves, may control for validity threats. However, interdisciplinary approaches may be constrained by the lack of successful communications across disciplines. Communication links across disciplines are not only

needed but, most important, actual understanding is essential. This implies that the basic concepts utilized within individual disciplines need to be comprehended across disciplines. Otherwise it is like having telephones with every one speaking different languages.

It is postulated that assessment of validity as a disciplinary emphasis may provide an indication of whether those communications exist and, more importantly, whether they result in understanding. Validity per se may be an indicator of internal (intradisciplinary) as well as external (interdisciplinary) knowledge renewal and growth. Assessing the emphasis on validity within an individual discipline may give an indication of the openness of that discipline and thus, its likelihood for receiving and eventually, adopting new knowledge which has originated outside its domain. In addition, assessment of validity across disciplines may give an indication of the extent of complementarity and thus, of each discipline's ability to achieve interdisciplinary knowledge integration.

Assessing when and how validity has been introduced and what its emphasis has been in various fields allows us to test whether the resulting patterns are compatible with diffusion of innovations theory. This theory postulates that when innovations are adopted through personal communication patterns (i.e., person-to-person) the resulting adoption pattern follows an "S"-shaped curve.[6] That is, there are a few "early" adopters (i.e., the adoption curve shows a rather flat early phase) and later, when more adopters are recruited ("late" adopters), an exponential growth phase is observed but only after some "lag time" has elapsed.[7] Alternatively, when adoption follows a non-personal communication pattern, a massive early adoption is observed (i.e., there is no significant delay between "early" and "late" adopters). By considering disciplines as "adopters," we may determine whether individual (or groups of) disciplines have adopted new concepts (such as "validity") inefficiently (i.e., following an "S"-shaped curve) or efficiently (i.e., following a massive early adoption). Thus, assessments of adoption profiles (as expressed by publication trends) may estimate the extent of efficiency in adoption of new concepts such as "validity."

In addition, this study represents an evaluation of potential tools applicable in policy planning and evaluation of professional research. It is hypothesized that this set of indicators may allow us to rapidly identify disciplines which may perform above or below average. When below average performance is identified, this tool could facilitate further discipline-specific evaluations. Conversely, when above average performance is identified, the same tool could direct our attention to further, confirmatory discipline-specific evaluations aimed at uncovering the reasons for those successful experiences in order to disseminate rapidly the learned lessons.

For remedial or massive communication purposes, the early identification of potential "early" or "late" adopters among disciplines facilitates the generation of recommendations and thus, it may be a tool for anticipatory science policy planning.

In sum, this study has three objectives: 1) identification of the adoption patterns of validity-related contents of research publications; 2) development and testing of indicators expected to facilitate early identification of disciplines or fields which may require further context-specific evaluations; and 3) production of specific recommendations seeking to optimize the validity of published research.

Materials and methods

Meta analysis of validation-related content in dissertations and articles was the method of choice for this study.[8] Validation-related contents were searched through multiple bibliography databases. Since many words, such as **valid, validity, validated, validating** and **validation** contain the prefix **valid**, the truncated keyword **valid*** was searched for either in the title or in the abstract of dissertations and articles.

Selection of databases

Three major databases which index dissertations and articles were selected: 1) *Dissertation Abstracts International*, 2) *Social Science Citation Index*, and 3) *Science Citation Index (Expanded)*. *Dissertation Abstracts International* is a multidisciplinary database with citations and abstracts compiled from over 1000 participating institutes. The *Social Science Citation Index* contains about 3.15 million articles from 1988 to date, scanned from nearly 1725 journals covering 50 disciplines. The *Science Citation Index (Expanded)*, indexes more than 5700 journals across 164 specific disciplines since 1988. Currently, it contains about 12 million articles. Dissertations were scanned from *Dissertation Abstracts International* while journal articles were searched for in *Social Science Citation Index* and *Science Citation Index (Expanded)*.

Selection of subject fields

After reviewing the data structure and subject field codes in these databases, 13 subject fields were selected for further analysis. These subject fields were grouped under three major subject field groups. Details of subject field grouping and keywords

for subject fields are displayed in Table 1. Data scanned were further restricted to the literatures in English language only.

Table 1
Subject fields and subject field groups

Subject field groups	**Subject keywords**
Agricultural Sciences	Agriculture Animal Science or Veterinary Medicine Forestry or Forest* Fisheries
Applied Sciences	Engineering Health Sciences or Medicine Management Computer Physics
Social Sciences	Education Psychology Sociology Economics

Data collection

Dissertations were scanned on a yearly basis since 1959, and articles, since 1988. The total number of publications and publications with validation-related contents, were assessed for each subject through multiple searches combining various fields (i.e., year of publication/degree date, language and subject field code).

Computation of parameters

Percentage of dissertations and articles having validation-related contents were computed for each subject field, each subject field group, and all subject fields together on yearly basis and also averaged over the time horizon of the study.

The Annual Compound Growth Rate (ACGR) of number of dissertations and articles was computed after exponential smoothening of the data. The equation for least-square exponential trend line is $y = b \times m^x$, where b and m are constants, and x is years. The value of m equals to $(1 + r/100)$ where r is the growth rate percent, and $r = (m - 1) \times 100$. To determine the growth trends in recent years, data from 1991 to 1998 were analyzed.

The time lag between reporting of validation-related contents in dissertations and that of articles was computed for individual subject fields as the difference between the intercept of the regression line for dissertations and that of articles of the same subject where the X-axis represented time.

Results

Data pertaining to 551,212 dissertations and 440,155 articles covering 13 subject fields, were analyzed in this study. Results are discussed separately for dissertations and articles across individual subject fields and subject field groups.

I. Dissertations emphasizing validated knowledge

Adoption in individual fields

Date of initial adoption by individual fields. The percent of dissertations that include the keyword **valid*** in their title or abstract (here named Valid-Dis) since the 1950's, is presented in Fig. 1. Different starting dates were noticed among fields. Psychology and Education were the first fields where Valid-Dis was introduced (late 1950's). Engineering followed in the early 1960's. At the end of the 1960's Medicine and Health Sciences, Physics, and Economics began to show Valid-Dis. Management in turn, began in the early 1970s. The first dissertations with validity-related contents from Agriculture and Forestry appeared in the late 1970s. In the early 1980s Animal Science, Veterinary Medicine and Fisheries adopted Valid-Dis. After 1985, Valid-Dis have been consistently reported in all fields of study.

Longitudinal adoption trends. The percentage of Valid-Dis over time has varied within individual fields as well as between fields (Fig. 1). The increase of Valid-Dis in Medicine and Health Sciences took place first, between 1965 and 1970. At that time, Medicine and Health Sciences had the highest percent of dissertations among all fields with the keyword **valid***. A second wave followed between 1975 and 1980, when most other fields registered sharp increases in the percentage of Valid-Dis. However, since the mid 1980's a steady phase has been observed for most fields, which in several cases is characterized by a slight decrease in percentage of dissertations which emphasized validation. These findings demonstrate that adoption of this concept as a dissertation content did not occur at the same time or with similar emphasis among all fields.

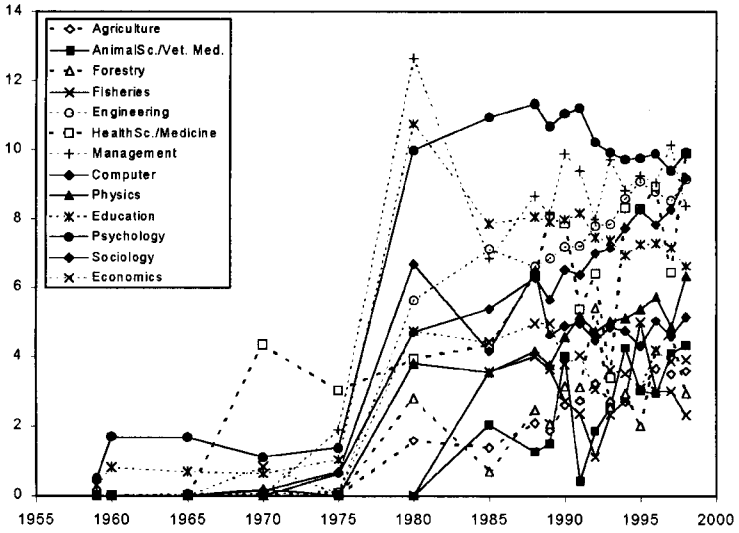

Fig. 1. Dissertations with validity-related contents (1959-1998) categorized by individual subject fields. Percentage of dissertation titles and abstracts containing the truncated keyword **valid***. Source: *Dissertation Abstracts International*

Adoption in field groups

A data-based grouping of individual subject fields according to their adoption trends allowed us to identify three major groups of subject fields. The first group, here named Social Sciences, includes Psychology, Education and Economics. Except for the last five years, this group has shown the highest percent of Valid-Dis (Fig. 2). The second group, named Applied Sciences (which include Engineering, Health Science/Medicine, Management, Computer, Physics) has shown the second highest percent of dissertations with contents related to validated knowledge over time. This group also showed the highest percent in the last five years. The third group, Agricultural Sciences (which includes Agriculture, Animal Science/Veterinary, Forestry, Fisheries), has shown the lowest Valid-Dis percent throughout the entire period under study. These data demonstrate consistent similarities over time within fields and consistent differences over time between fields included in different groups.

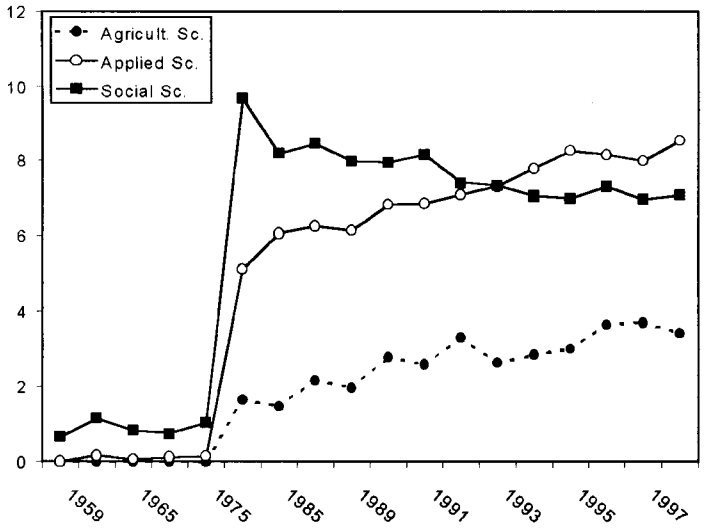

Fig. 2. Percent of dissertations with validity-related contents (1959-1998) categorized by subject field groups. Agricult. Sc. include: Agriculture, Animal Science/Veterinary Medicine, Forestry, Fisheries. Applied Sc. include: Engineering, Health/Medicine, Management, Computer, Physics. Social Sc. include: Education, Sociology, Psychology.
Source: *Dissertation Abstracts International*

Recent trends

The annual compound growth rate (ACGR) of dissertations published between 1991 and 1998 is shown in Fig. 3. While the overall ACGR of all dissertations (with and without validity-related contents) has been positive for all subjects considered together (0.9%), when the ACGR is broken down into field groups it is noted that Social Sciences have had a negative trend (–0.05%) in Valid-Dis during the last decade (Table 2). Dissertations with validity-related contents grew in Agricultural Sciences and Applied Sciences (>3%) more than in Social Sciences during the last decade. When individual subject fields were assessed, Animal Science/Veterinary, Agriculture, Computer and Education showed negative growths in the overall number of dissertations (with and without validity-related contents) during last decade (Table 2). However, when Valid-Dis only was assessed, Education was the only subject field

which has shown negative growth rates during this period (–3.1%). It was interesting to note that, in spite of an overall negative growth rate for all dissertations (with and without validation-related contents), Animal Science/Veterinary Medicine showed a strong positive growth rate for Valid-Dis (20.6%, Table 2).

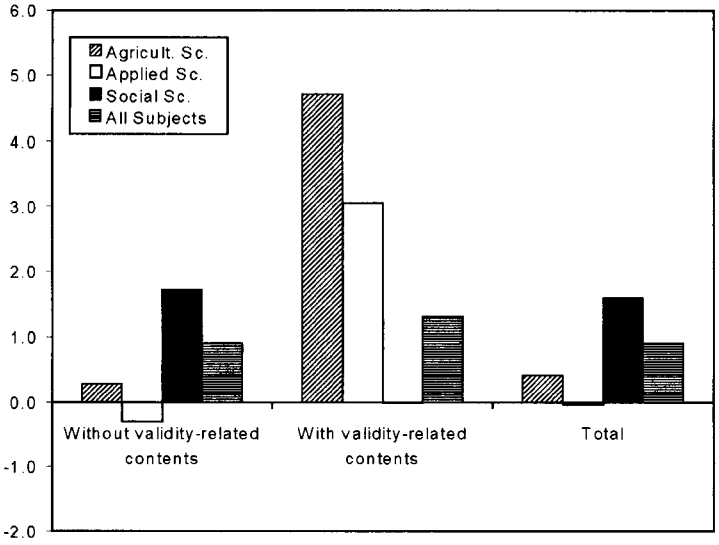

Fig. 3. Annual compound growth rate of dissertations categorized by contents and subject group fields (1991-1998). Percent of dissertation contents with ("with valid*") and without validity-related contents ("without valid*")

II. Journal articles emphasizing validated knowledge

Adoption in individual fields

Date of initial adoption by individual fields. The percent of articles, published during 1988-1998 in various subject fields, with validation-related contents in their title or abstract (here named Valid-Art) is shown in Fig. 4. Since it was under one percent for all fields until 1988, no previous data are reported. A sharp increase was registered in 1991 for most fields. Contrary to the staggered adoption trends observed for dissertations, journal articles introduced Valid-Art at approximately the same time in most fields.

Table 2
Annual compound growth rate (ACGR) of dissertations (1991–1998)

Subject fields	Annual compound growth rate, %		
	Without emphasis on validation	With emphasis on validation	Overall
Agriculture	–0.2	4.0	–0.1
Animal Science/Veterinary	–6.0	20.6	–5.6
Forestry	3.0	3.0	3.0
Fisheries	5.8	14.1	6.0
Engineering	–0.2	3.1	0.1
Health Science/Medicine	3.0	12.9	3.6
Management	5.9	6.2	6.0
Physics	–1.8	0.7	–1.7
Education	–1.0	–3.1	–1.2
Psychology	1.9	0.2	1.7
Sociology	7.7	8.3	7.8
Economics	0.4	2.0	0.5
Computer	–2.9	1.9	–2.5
Subject field groups			
Agricultural Sciences	0.3	4.7	0.4
Applied Sciences	–0.3	3.1	–0.05
Social Sciences	1.7	–0.02	1.6
All subject field groups	0.9	1.3	0.9

Source: *Dissertation Abstracts International*

Longitudinal adoption trends. After 1991, the increase in percentage of articles with validity-related contents continued for Psychology but it has been marginal in most fields and it has shown an actual decrease in Animal Science/Veterinary Medicine, Agriculture and Physics. Three distinct profiles of subject fields were noticed from the data. The first profile included Psychology, with about 8% of articles having validity-related contents. The second profile included Computer Sciences, Engineering, Health Science/Medicine, and Education, where nearly 4% of the articles included validity-related contents. The remaining fields, constituting the third profile, had annual values near 2% (Fig. 4). These findings indicate that individual subject fields and field groups showed distinct article and dissertation publication profiles over time.

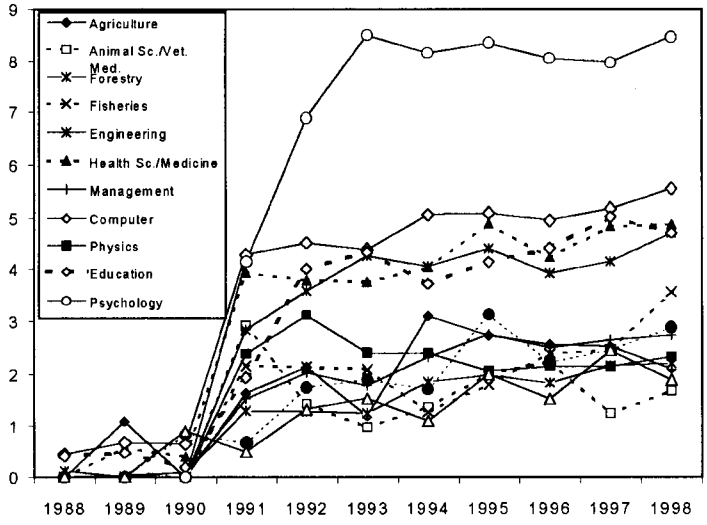

Fig. 4. Articles with validity-related contents (1988-1998) categorized by individual subject fields. Percentage of article titles and abstracts containing the truncated keyword **valid***. Source: *Social Science Citation Index* and *Science Citation Index (Expanded)*

Adoption in field groups

Analysis of article publication profiles (based on field groups) revealed almost the same profiles seen with dissertations (Fig. 5). All groups showed a sharp rise in validation-related contents during 1991 followed by a marginal increase thereafter. The percent of Valid-Art has been consistently higher for Social Sciences, followed by Applied Sciences. However, the higher value for the Social Sciences group is mainly contributed by Psychology. When this field is excluded, there is no significant difference between other Social and Applied Sciences. On the other hand, the percent of articles with validity-related contents has been minimal for Agricultural Sciences.

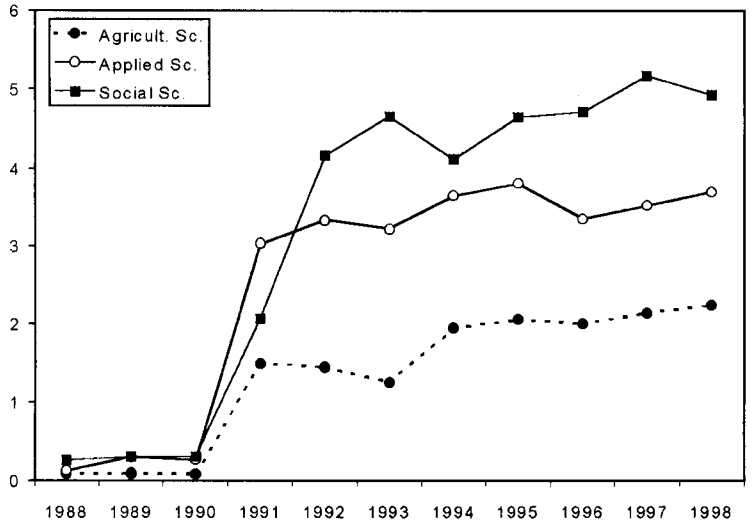

Fig. 5. Percent of articles with validity-related contents (1988-1998) categorized by subject field groups. Agricult. Sc.: Agriculture, Animal Science/Veterinary Medicine, Forestry, Fisheries; Applied Sc.: Engineering, Health/Medicine, Management, Computer, Physics; Social Sc.: Education, Sociology, Psychology.
Source: *Social Science Citation Index* and *Science Citation Index (Expanded)*

Recent trends

The annual compound growth rate (ACGR) of number of articles published with validation-related contents (Valid-Art) and without validation-related contents (Nonvalid-Art), is summarized in Table 3. The overall growth rate of articles ranged between 4.0% to 46.9%, averaging at 12.6%. Except for Animal Sciences/Veterinary Medicine, and Physics, in all the other fields the ACGR of Valid-Art has been significantly higher than that of Nonvalid-Art. In Animal Science/Veterinary the growth rate for Valid-Art (11.5%) was less than that of Nonvalid-Art (13.8%). In Physics, the difference between these indicators has been about 4.5%. When field groups were analyzed, Applied Sciences showed lower ACRG for Valid-Art than the other field groups (Fig. 6). In all field groups the growth rate of Valid-Art was higher than those of Nonvalid-Art during last decade.

Table 3
Annual compound growth rate (ACGR) of journal articles (1991–1998)

Subject fields	Annual compound growth rate, %		
	Without emphasis on validation	With emphasis on validation	Overall
Agriculture	10.5	17.1	10.6
Animal Science/Veterinary	13.8	11.5	13.7
Forest*	9.8	20.2	10.0
Fisheries	24.3	32.1	24.5
Engineering	10.6	16.4	10.8
Health Science/Medicine	11.4	16.0	11.6
Management	9.9	19.1	10.1
Computer	3.8	7.6	4.0
Physics	47.0	42.5	46.9
Education	10.5	21.3	10.8
Psychology	9.1	17.1	9.5
Sociology	9.0	27.7	9.3
Economics	8.8	27.3	9.0

Sources: *Science Citation Index (Expanded)* and *Social Science Citation*

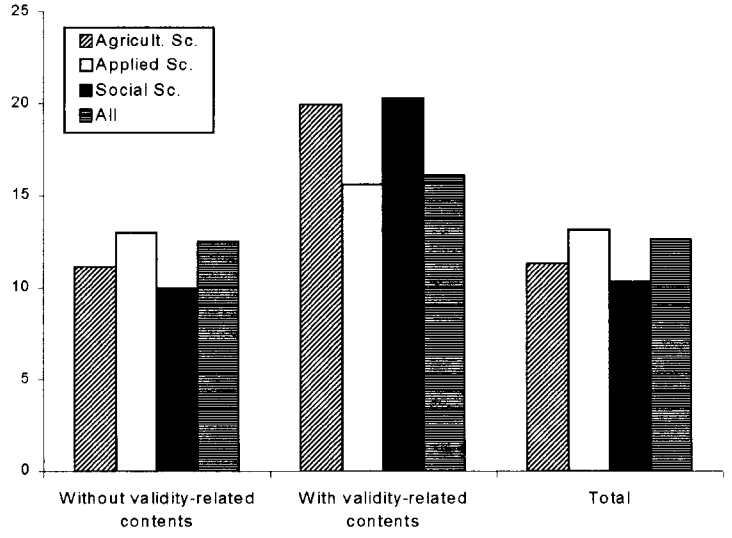

Fig. 6. Annual compound growth rate of articles categorized by contents and subject group fields (1991-1998). Percent of article contents with ("with valid*") and without validity-related contents ("without valid*")

III. Relationships between dissertations and articles

Field clustering based on composite publication trends of validity-related contents

Four clusters of subject fields were constructed based on the composite publication trends of articles and dissertations with validity-related contents. The clustering was made with reference to the relative position of individual fields in comparison to the average of all fields (Fig. 7). In Engineering, Computer, Health Science, Psychology and Education, the percentage of both dissertations and articles with emphasis on validated knowledge has been above average. The profile of Agriculture, Animal Science/Veterinary Medicine, Forestry, Fisheries, Physics, Economics and Sociology has been below average for both dissertations and articles. Management showed percentages of dissertations above average, and below average for articles. No field appeared in the quadrant of high number of articles and low number of dissertations. A highly statistically significant positive corelation was found between dissertations and articles ($r^2 = 0.98$).

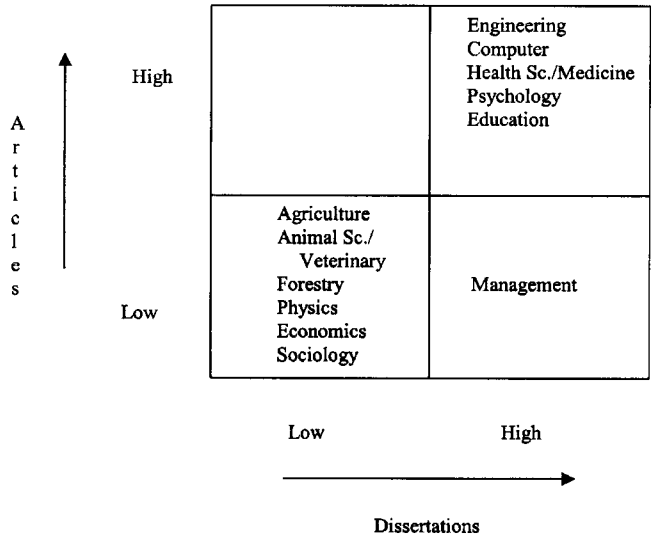

Fig. 7. Clustering of subject fields according to emphasis on validity-related contents. The mean percent of articles/dissertations including the truncated keyword **valid*** of thirteen subject fields was chosen to create quadrants of low vs. high emphasis

Ratio of Articles to Dissertations among fields

During the last decade, the number of dissertations with validity-related contents was greater than that of articles in most subject fields (Table 4). With the exception of Health Sciences/Medicine, and a few other fields, most subject fields showed a ratio <1 (i.e., less than one article with validity-related contents per dissertation with validity-related contents in the same field).

Table 4
Articles/Dissertations ratio (1991–1998)

Subject fields	Ratio		
	Without emphasis on validation	With emphasis on validation	Overall
Agriculture	0.23	0.17	0.23
Animal Science/Veterinary	1.52	0.83	1.50
Forest*	6.23	3.05	6.12
Fisheries	1.34	1.06	1.33
Engineering	0.28	0.13	0.27
Health Science/Medicine	38.57	21.52	37.33
Management	7.26	1.63	6.75
Computer	3.70	2.28	3.60
Physics	1.68	0.72	1.63
Education	0.32	0.16	0.31
Psychology	0.12	0.08	0.11
Sociology	0.05	0.02	0.05
Economics	0.22	0.08	0.21
Subject field groups			
Agricultural Science	1.26	0.74	1.25
Applied Science	2.09	0.89	2.00
Social Science	0.19	0.10	0.19
All subjects	0.98	0.43	0.95

Annual Compound Growth Rate (ACGR) of Articles and Dissertations with contents related to validated knowledge

In spite of the overall results reported above, the growth rate of articles has been significantly higher than that of the dissertations in all fields, regardless of their emphasis on validated knowledge. Thus, if the growth rates observed remain, it could be expected that at some point the ratio of articles per dissertation should be greater than it

has been until now. For dissertations emphasizing validation the growth rate during the last decade was about 1.3% in comparison to 16.1% for articles emphasizing validation. The growth rate for dissertations and articles without emphasis on validation was 0.9% and 12.5%, respectively (Figs 4 and 6).

Time lag between dissertations and articles with validation-related contents

All fields showed that the introduction of validation-related contents in journal articles took place several years after dissertations had shown significant percentages of validation-related contents (Figs 1 and 4). The estimated time lag between the initial adoption of validation-related contents in dissertations and articles of various subject fields is presented in Table 5. The time lag for individual subject fields varied between 5.7 years for Health Science/Medicine and 27.4 years for Education. The average time lag considering all fields was estimated at 11.3 years. Among field groups, the time lag was maximal for Social Sciences (15.1 years) and minimal for Agricultural Sciences (8.4 years).

Table 5
Publication time lag between dissertations and articles with validity-related contents

Subject fields	Time lag in years
Agriculture	10.5
Animal Science/Veterinary	7.7
Forest*	9.2
Fisheries	15.1
Computer	16.2
Management	11.5
Health Science/Medicine	9.7
Engineering	10.4
Physics	5.7
Education	8.2
Psychology	23.7
Sociology	27.4
Economics	21.1
Subject field groups	
Agricultural Science	8.4
Applied Science	10.7
Social science	15.1
All subjects	11.34

Discussion

Caveats

This study has been conducted based on the assumption that searches for the truncated keyword **valid*** would retrieve publications having emphasis on some aspect of knowledge validation. However, the intrinsic validity of this construct is uncertain. Searches might yield underestimated results if publications did not include this keyword in their text even if they actually included validation-related contents. Vice versa, overestimated results could have occurred if the keyword **valid*** had been used out of the context here investigated. Thus, this report should not be construed as a measurement of the actual literature emphasizing knowledge validation but only as a screening tool whose purpose is to facilitate hypothesis or question generation. Therefore, this is not a confirmatory study, but a data-driven approach to generate questions which may require further qualitative and quantitative confirmatory investigations.

Nevertheless, an attempt was made to control and eventually, improve the validity of our research construct by virtue of investigating independent databases. By searching databases that contained different types of publications (dissertations and articles) we hypothesized that if results showed no associations, they could be interpreted either as an evidence of factor(s) other than validity explaining that lack of association (i.e., different emphasis in graduate education than in research), or as an evidence of lack of validity. Conversely, if results showed an association, they could be interpreted as an evidence of factors (validity included) explaining the association. The fact that a virtually perfect linear positive association was found between dissertations including the keyword **valid*** and articles with the same keyword, appears to support that, although undetermined in magnitude, the validity of our construct could not be discarded.

Adoption of validity appears to follow an interpersonal communication style

In regard to our first research objective, the introduction and growth of publications related to knowledge validation appeared to follow a pattern compatible with a dissemination profile predicted by diffusion of innovations theory.[6] In our context, the concept of "validity" could be regarded as another "innovation" while individual fields (as well as groups of fields) could be regarded as "adopters." This implies that fields and field groups may be regarded as cultural entities whose "adoption of innovation" profiles are intrinsically no different than those of other human groups (i.e., farmers, consumers, patients).

This argument is supported by the following findings: 1) most fields showed consistent "adoption" profiles over time (i.e., they showed a similar publication profile over time); 2) time gaps between "early adopters" and "late adopters" were clearly demonstrated within fields; 3) clusters or groups of fields showing consistent similarities within the group and consistent differences between groups were also easily observable; and 4) once the "innovation" was "adopted" (regardless of being an "early" or "late" adoption), it remained adopted thereafter.

Two hypotheses are generated based on these observations. The first hypothesis is that there has been, or is, a wasted or missed opportunity for generating more valid knowledge due to not adopting the "innovation" earlier. This hypothesis is grounded on the data that showed protracted gaps between "early" and "late" fields.

The second hypothesis is that these difficulties in adopting validity as a major focus of graduate and post-graduate research may pose a barrier to interdisciplinary knowledge synthesis. That is, they may represent a consistent impediment to achieve knowledge of greater impact, as interdisciplinary knowledge is expected to be. This means that even when we have the basic knowledge necessary to address complex problems (that is, problems that require interdisciplinary knowledge integration), the lack of communication among fields (documented by the time lag in adoption of validity as a publication content across disciplines) are preventing us from assembling the interdisciplinary knowledge required to address those complex problems.

Science policy planning and evaluation: application of the indicators

In regard to our second research objective, the indicators here utilized appeared to have facilitated the identification of fields and field groups where above-average or below-average performance has occurred, so that learning lessons can be identified as well as remedial actions generated. These indicators appear to have at least, three potential applications. First, they may save time in the process of identifying individual under-achievers and over-achievers, so that actions can be expedited. Second, they may help identify clusters or groups of fields that share similar behaviors as well as those that consistently show different behaviors. Third, they may indicate whether the problem or excellence is internal or external in relation to a given field, which should facilitate generation of situation-specific actions. For instance, the delay observed within some individual fields between the time dissertations showed a rapid rise in validity-related contents and that of articles, clearly suggests that the barrier to faster adoption is *internal* to those individual fields (i.e., the fact that dissertations within an individual field had already shown publications, demonstrates that "validity" was not a concept alien to that field). Conversely, the fact that individual fields showed percentages of

publications related to validity consistently lower than those of other fields over time, appears to suggest that barriers *external* to those disciplines prevented the introduction of "validity" as a concept since other fields at the same time had already introduced it.

The utilization of the articles/dissertations ratio and the annual growth rate of dissertations as well as that of articles allowed us to easily distinguish a variety of situations. For instance, the articles/dissertations ratio allows us to compare between fields in order to hypothesize which graduate program (where dissertations are conducted) is more associated with professional research (i.e., when dissertations have a greater impact, as reflected in journal articles, on research). In contrast, regardless of the total number of dissertations and articles and their ratios, the annual growth rate (for either dissertations or articles) allows us to identify whether there is an increasing or decreasing trend. Together, these indicators may provide information which allow us to generate questions which may facilitate further, subject- or subject field-specific evaluations.

Recommendations

The graduate training and the peer-reviewing process appeared to be two strategic factors in the process of adopting validity as an explicit focus of research. As a whole, dissertations with emphasis on validation showed a high correlation with articles with the same emphasis. Dissertations also preceded journal articles by many years. This implies that the contents emphasized in graduate training may clearly influence the outcomes of professional research. Thus, by influencing graduate training, the contents of research articles should eventually be modified, too. However, this process appeared to be extremely slow. Delays in adoption of ten years or more were noticed for several fields. Thus, it is postulated that peer-reviewers themselves are those who can be instrumental in a more rapid adoption process. While this study did not investigate the awareness or expertise of peer-reviewers themselves in issues related to knowledge validation, the fact that, on average, more than 96% of journal articles did not include explicit contents related to validation supports the hypothesis that peer-reviewers may lack the training required to monitor the validity of published research.

Therefore, discipline-specific institutional policies are recommended to target both academicians and journal reviewers. Those actions could include both strategic communications campaigns and special continuing education programs on evaluation theory. This implies the development of discipline-specific units integrated by interdisciplinary teams where both the specialized expertise and expertise in evaluation theory can be mastered in order to generate educational programs and communication campaigns built on discipline-specific examples.

Conclusions

Specialized knowledge appears to be associated with barriers that prevent the most efficient utilization of knowledge already available. The fact that many fields showed delayed or poor emphasis on validated knowledge, support the contention that these barriers may not be removed spontaneously. The set of indicators utilized here appeared to facilitate the identification of problem areas and success lessons. Discipline-specific institutional policies are recommended to provide academicians and journal reviewers with continuing education on evaluation theory.

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Received November 30, 1999.

Address for correspondence:
ARIEL L.RIVAS
College of Veterinary Medicine, Cornell University, Ithaca, NY 14853 (USA)
E-mail: alr4@cornell.edu