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Influence of interdisciplinarity on peer-review and bibliometric evaluations in physics research

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Abstract

It is often argued that interdisciplinary research is valued less in both qualitative (peer-review based) as well as in quantitative (bibliometric) assessments. A recent extensive, nation-wide evaluation of all academic physics groups in the Netherlands allowed us to investigate this problem empirically. Therefore, we first developed an operationalization of 'interdisciplinarity'. On the basis of our findings, we refute the above statement, at least for the field and the country involved. We found that (i) peer judgements do not significantly correlate with the degree of interdisciplinarity; (ii) only elementary bibliometric indicators correlate negatively, but (iii) 'advanced' indicators do not correlate with the degree of interdisciplinarity, except a small correlation in the case of large programs. Thus, we found no general evidence for a peer-review bias as well as a bibliometric bias against interdisciplinary research.

1. Introduction

Should interdisciplinary research be reviewed the same way as disciplinary research? This topic has become increasingly important as national research policies lay more emphasis on problem-oriented research which often exceeds traditional boundaries between disciplines (Weingart and Stehr, 2000). The question is also a topical subject in a recent evaluation of physics research held in the Netherlands (VSNU, 1996). Assessments of research programs by peer-review have been supplemented with an extensive bibliometric analysis. Our methods (van Leeuwen et al., 1996) go far beyond the rather simple notions of bibliometric analysis as described by the Committee on Science, Engineering, and Public Policy (COSEPUP) of the US National Academy of Sciences in its recent report on evaluating federal research programs (COSEPUP, 1999).

In general, peer judgements are rather well in agreement with the outcomes of bibliometric indicators (Rinia et al., 1998). However, for *interdisciplinary* programs some specific contrasting results were found (Porter and Rossini, 1985). We now analysed the results of this nation-wide physics evaluation particularly from the perspective of interdisci-

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plinarity. The concept of interdisciplinarity is operationalized as the extent to which articles are published in journals in *other* scientific fields than the main field (physics) of a program.

2. Methodological Approach

The quality assessment procedure of the universities in the Netherlands consists of a discipline-wise judgement of research performance by international committees of independent experts. In this context an evaluation of Dutch academic physics was carried out by the International Review Committee for Physics (VSNU, 1996). In an additional bibliometric analysis, which was made available in a final round to the Committee, we gathered data for about 200 academic physics research programs, covering more than 15,000 publications in the period 1985–1994. For a detailed presentation of the applied bibliometric approach and in particular the construction of the advanced indicators, we refer to van Leeuwen et al., 1996, also available via our website[1], and to van Raan, 1996.

We now used these bibliometric data to construct, for each program, a 'research profile' which represents the frequency distribution of publications over research (sub)fields (defined by journal classification according to the 'journal categories' of the Institute of Scientific Information, ISI). On the basis of ample empirical experiences with the thus defined research profiles see (van Raan, 1996, and our contribution to Weingart and Stehr, 2000) we claim that this approach provides a sufficiently reliable representation of interdisciplinarity. In Table 1 we present as an example one of the research programs with 476 publications, 271 of which can be assigned to physics (i.e., the journals concerned belong to physics fields), and 205 are published in journals which belong to *non-physics* fields. So the percentage of 'non-physics' papers is 43%. We define the percentage of *non-physics* papers as the degree of interdisciplinarity. The analysis was restricted to 185 programs with 10 or more publications, with an average number of 96 publications. As can be observed in Table 1, interdisciplinarity in this study does not cover a very broad spectrum of fields. It is confined to fields rather closely related to physics, such as engineering and chemistry.

Table 1
Distribution of publications of an arbitrary programme over research (sub)fields. Publications may be attributed to more than one (sub)field. In that case they are fractionally counted

Subfield	Main Field	Number of Publications
PHYSICS, PART & FI	PHYS	17.0
PHYSICS, NUCLEAR	PHYS	3.3
PHYSICS, MISCELL	PHYS	1.0
PHYSICS, MATHEMA	PHYS	1.0
PHYSICS, COND MA	PHYS	146.2
PHYSICS, AT,M,C	PHYS	4.3
PHYSICS, APPLIED	PHYS	50.5
PHYSICS (GEN.)	PHYS	47.3
Subtotal physics subfields		270.7
MULTIDISCIPL SC	MULT	5.5
METALLURG & MINING	META	55.8
MATERIALS SC	MATE	66.8
MATER SC, COATING	MATE	0.8
ENGINEERING	ENGI	5.5
ENG, ELECTRICAL	ENGI	6.5
ELECTROCHEMISTRY	ELEC	0.5
CRYSTALLOGRAPHY	CRYS	1.0
COMPU SCI, INT AP	COMP	1.0
CHEM,PHYSICAL	CHEM	61.0
CHEM, INORG & NUC	CHEM	0.5
ASTRON & ASTROPH	ASTR	0.3
Subtotal non-physics subfields		205.3
Total		476.0

3. Empirical findings

The distribution of interdisciplinarity of physics research programs in the Netherlands is given in Fig. 1. The average degree of interdisciplinarity per program is 36%. For 93 programs a quality judgement was given by the International Review Committee for Physics, which was compared to the interdisciplinarity of these programs. Calculating a Spearman rank-correlation coefficient between these two variables we find $r_S = -0.13$. We conclude that the

[1] Our webside is http://sahara.fsw.leidenuniv.nl/cwts/cwtshome.html.

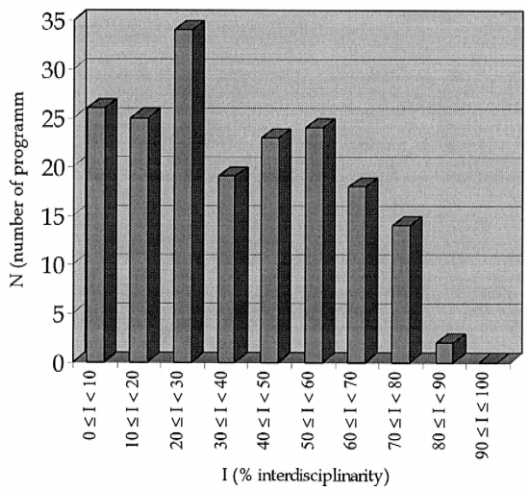

Fig. 1. Degree of interdisciplinarity of research programmes in physics in the Netherlands (1985–1994).

peers did not judge interdisciplinary programs differently than 'monodisciplinary' programs. It may also be concluded that, according to the peers, the quality of the more interdisciplinary programs is, on average, equal to that of other more 'monodisciplinary' ones.

Next we compared results of the whole set of bibliometric indicators (van Leeuwen et al., 1996; van Raan, 1996) applied to all 185 physics research programs with the degree of interdisciplinarity of these programs. Linear correlation coefficients (r) of logarithmic values of the indicators (Stewart, 1993) and interdisciplinarity are given in Table 2, where we also distinguish between classes of program size (in terms of number of publications). It appears that in several cases the correlation coefficient is significantly *negative*. This means that with *increasing interdisciplinarity* a *lower score of the bibliometric indicators* concerned is obtained.

There are, however, striking differences between the various indicators. First the more elementary indicators. The number of publications (P) per program does *not* significantly correlate with interdisciplinarity. The total number of citations (C) of a program, and the average number of citations per paper (CPP) show, in the case of the larger programs, a small but significant *negative* correlation. Correlation coefficients also show that work in interdisciplinary programs is published in fields characterised by a lower field-specific average number of citations (FCSm), and in journals with a lower journal-specific citation mean (JCSm). The latter indicator shows the largest (negative) correlation. These correlations may partly be related to the well-known phenomenon that citation characteristics vary by journal and field. In applied fields for instance, they are often lower than in basic science fields.

More *advanced* bibliometric indicators correct for these differences by taking world-average citation rates of journals or fields as a reference level (van Leeuwen et al., 1996). Two of such indicators, used in the bibliometric analysis of Dutch academic physics, compare citation averages of a research program with citation averages of its journals (CPP/JCSm), and with citation averages of its field (i.e., *all* journals in a specific field, CPP/FCSm). We find that the outcomes of these indicators are considerably *less* correlated with interdisciplinarity. There is *no* significant correlation between interdis-

Table 2
Linear correlation coefficients (r) between interdisciplinarity and bibliometric indicators (logarithmic values). The number of publications per program (three size classes) is indicated by n. The number of programs in each class is indicated by N. Correlations significant at a confidence level of 99% are indicated with a '+' sign. The various bibliometric indicators and their symbols are briefly explained in the text and extensively discussed in van Leeuwen et al., (1996) and van Raan (1996)

Number (n) of publications per program	Number (N) of programs	I(% interdisciplinarity) vs.							
		P	C	CPP	JCSm	FCSm	CPP/JCSm	CPP/FCSm	JCSm/FCSm
10–50	60	−0.17	−0.17	−0.28	−0.43 +	−0.40 +	−0.01	−0.10	−0.23 +
50–100	62	−0.15	−0.39 +	−0.37 +	−0.56 +	−0.45 +	0.00	−0.17	−0.36 +
≥ 100	63	−0.17	−0.53 +	−0.52 +	−0.51 +	−0.27	−0.28	−0.47 +	−0.49 +

ciplinarity and the indicator normalizing the measured impact of publications of a program to the world-wide citation averages of the journals involved (see Table 2, column CPP/JCSm).

This result clearly indicates that interdisciplinary research, at least in Dutch physics, has the same impact as 'monodisciplinary' research when citation scores are compared with citation averages of the journals concerned. We conclude that impact normalisation on journal characteristics (and article type as well) indeed takes into account the scope of the research, in this case the more interdisciplinary character.

Measured by the other advanced indicator which normalizes on field citation characteristics (i.e., *all* journals in a specific field, CPP/FCSm), interdisciplinarity only shows a small significant, negative correlation in the case of the larger programs. Our explanation is that in such cases field averages are dominated by the larger monodisciplinary journals, and we conclude that 'fields' (defined as larger sets of journals) are probably too 'broad' to have an interdisciplinary focus.

Finally, interdisciplinarity and the indicator comparing the journal citation average to the field citation average (JCSm/FCSm, in fact a measure of the 'status' of the journals used by the researchers in a program), correlate slightly but significantly negative. This again indicates that interdisciplinary research is often published in journals with a citation level below the average of the fields involved. As already noticed in the discussion on the elementary indicators, the results presented in Table 2 show that negative correlations between interdisciplinarity and outcomes of a number of indicators, generally tend to *increase* for larger programs (in terms of publication output).

4. Conclusions

Our results demonstrate that peer judgements of Dutch academic physics by a panel of international experts show no significant correlation with the degree of interdisciplinarity of the programs concerned. In other words, it shows that there is no general bias concerning interdisciplinary projects in this quality assessement. Porter and Rossini, (1985) found some evidence that interdisciplinary proposals are downgraded in peer review because reviewers tend to rate proposals from their own discipline more favourably. However, these findings are based on a more 'focused' peer-review procedure which differs from the above-mentioned evaluation with an expert panel assessing a broad, nation-wide discipline.

We showed that interdisciplinary research in the framework of physics programs receives slightly but significantly lower scores on some elementary bibliometric indicators. To our opinion these negative correlations do not reflect differences in scientific impact as assessed by bibliometric indicators between 'monodisciplinary' and interdisciplinary research. They are mainly related to differences in citation characteristics between fields and between journals within these fields. This conclusion is supported by the finding that the peers do not judge interdisciplinary programs differently, in combination with the finding that the more advanced indicators which correct for differences between fields and journals, do not correlate significantly with the degree of interdisciplinarity.

Thus, both types of assessment do not show a significant bias with respect to interdisciplinarity. Evidently, impact normalisation on journal characteristics takes into account the scope of research, in this case the more interdisciplinary character. We conclude that for interdisciplinary research, the indicator CPP/JCSm (impact normalization on *journal* characteristics) appears to be the most appropriate bibliometric measure. The indicator CPP/FCSm (impact normalization on *field* characteristics) is slightly biased in case of (larger) interdisciplinary programs in Dutch physics. The correlations found between degree of interdisciplinarity and the outcomes of elementary citation-based indicators without journal- or field-specific normalization, may be a warning against poorly informed use of citation data, especially in the case of interdisciplinary research. Also the correlations found between interdisciplinarity and the average citation level of journals in which a group publishes, may be a warning particularly against the uninformed use in research performance evaluations of simple citation-based characteristics of journals, like ISI's journal impact factors (Moed and van Leeuwen, 1996).

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