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Significance of Colleges of Applied Sciences
(CAS, Fachhochschule) for Technology Transfer
to Third World Countries

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Abstract

Since 1970 the CAS has been introduced to Germany F.R. as an alternative form of academic education to university formation.

At present 120 CAS' offer 80 different subjects to more than 200 000 students. More than 40% of them are allotted to engineering courses. 51.8% of all students of engineering in 1979 were educated at the CAS! Between 1973- 1979 122 579 students out of a total of 147 561 graduated from CAS'. This underlines the important position, the CAS' hold in educational politics in Germany F.R.

Data, structure and facts about CAS will be exemplified subsequently. Methods and goals of education will be illustrated by example of the Division of Photogrammetry and Surveying Engineering at CAS, Hamburg. Experience, confirming the integration of practice into the study, is recorded. Further support of knowledge may be observed from interviews given by the students since 1979. Proposals for co-operation and technology transfer will be submitted subsequently.

1. Introduction

Technology signifies the use of scientific knowledge by a given society at a given moment to resolve its particular problem (1). Apart from the "Know-How", technology involves "Know-Why" and "Know-Where". The latter standing for description, provision, and working up of knowledge. Unlike science, technology always contains a human element (2).

The definition mentioned above points to strong social and cultural aspects. Technology transfer from Industry Nations to Developing Countries calls for its own clear language and must therefore break up the linguistic boundaries of the collective term "technique" which houses a diffuse medley of sorts under its roof.

The importation of technology also includes methods of learning and teaching, processing, and software packages, which imply a projection of sociotechnical and cultural values and behavior. That means, the specific secondary virtues of Industry Nations, such like capability to plan and to organize, moral, efficiency, and carrier-mindedness is included in the transfer(3). The procedure itself requires indispensable standards like to choose, acquire, adapt, absorb, assess, and manage technology.

Technology transfer is regarded by experts as a "diffusion-process", which effectiveness depends on the demands mentioned above (4). In short, for the countries in need, the complex represents a structural and cultural invasion that might have more prejudicial effects than colonialism in its time (3).

Transfer of technology must not be looked upon as a simple business transaction, but as a highly complicated affair, which requires technical-scientific qualification on the side of the donor as well as on the side of the recipient. These qualifications must be trained with utmost efficiency and consideration.

Prospective partners are challenged to make technology transfer a success on both sides. On the basis of its educational concepts, its goals in respect to development politics and technology transfer, the CAS is ready to take its share in a mutually fruitful dialogue on education with Developing Countries.

2. The CAS and Statistical Data

The Colleges of Applied Sciences exist since 1970. They are university institutions with stress on theoretical and academic constituents, accompanied by special practical training before and during study.

The instituting of this new type of academic education with its special accentuation on practice was a reaction to the

threatening outlooks on an educational backslide in the early sixties in the Federal Republic of Germany (FRG) as well as to the rapid progress of innovations in science and technology.

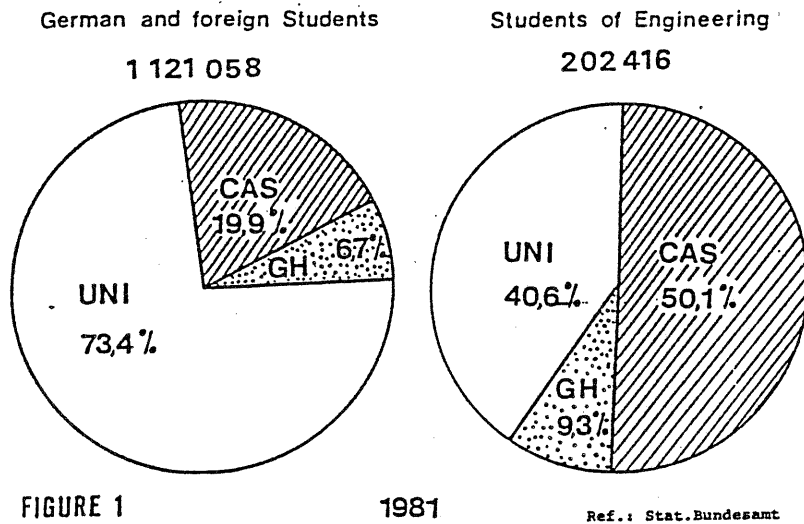


FIGURE 1

1981

Ref.: Stat.Bundesamt

The CAS is an autonomous corporation of the law (5). Self-government is conducted under legal supervision of the responsible administrative authority (Ministry of Culture and Education).

As a rule qualification for admission of students can either be obtained by graduation from a technical high school or from sec-

ondary schools in combination with practical training. To open other means of admission, so called technical high schools have been established which border on the areas covered by the CAS. Graduation from these schools has been adjusted to EEC-Standard, and qualification for CAS may be obtained after only 12 years instead of 13 years at secondary schools. Technical high schools offer general education as well as professional training. Beginners and students who did not attend a technical high school or received any preparatory practical training, are obliged to complete a course of practical studies related to their future profession. Practical studies should be completed before study begins. In general they do last 24 weeks.

Reference \ Year	1977	1978	1979	1980	1981	Annual Average
Number of Students	166 131	172 246	179 928	174 302	192 067	176 935
Number of Beginners in Study	41 508	40 444	43 844	44 383	42 199	42 476
Number of Graduated *	31 934	29 573	32 692	33 303	34 191	32 338
Students of Engineering	91 326	88 534	90 009	91 588	101 378	92 567
Number of Beginners in Study of Engineering	21 116	18 844	19 790	19 242	21 630	20 125
Number of Graduated Engineers	15 983	15 943	15 372	16 145	15 710	15 830
Number of Foreign Students	8 122	8 542	8 700	9 460	10 220	9 009
Number of Foreign Students in Eng.	6 495	6 528	6 538	6 839	7 467	6 773

* Only German Students Reference: Wissenschaftsrat (1981), Stat.Bundesamt (1983)

DATA RE. COLLEGES OF APPLIED SCIENCES

FIGURE 2

Fig. 1-4 give a clear idea about the position the CAS holds in regard to standards of academic education in the FRG. Out of a total of 1 121 058 students at the end of 1981, 192 067 (19.9%) took up studying at one of the 120 CAS's, enrolling in either of 80 courses offered (fig.1).

At the same time the number of students of engineering enlisted at the CAS equaled the number of students enlisted at Technical Universities (UNI) and GH-students (GH=UNI/CAS Coopera-

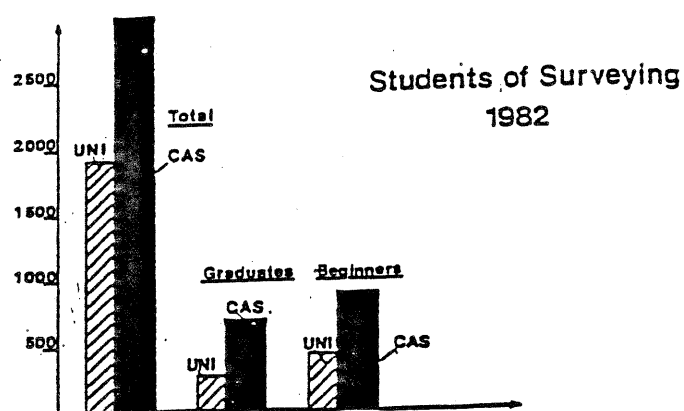


FIGURE 3

the CAS, were Latin Americans. With that, South America comes up at the end of CAS-statistics, after Africa (Europe 51%, Asia 33.8%, Africa 7.9%, USA and others 2.9%) The high demand for practice-orientated engineers is impressively demonstrated by the number of graduates since 1973: 109 905 out of 144 893 engineers graduated from CAS during 1973 to 1979 (6,7).

As far as the costs of study are concerned, CAS holds a strong argument, especially for tight budgeted countries. Calculation of costs of educating a qualified engineer at CAS can be called most favorable to the highly approvable results achieved (8).

As far as the branch of surveying engineering is concerned the following figures clearly demonstrate the significance of the CAS for german economy. Between 1945 and 1982, 15 008 surveying engineers out of a total number of 20 006 graduated from CAS's or its forerunners. The present rate of 3:1 (3 engineers from CAS to 1 engineer from UNI) is regarded, economically wise in respect to the present situation on the labour market in the FRG (9).

Fig.3 plus 4 compare the present situation of students of surveying engineering at the UNI and at the CAS. The discrepancy in the proportions between the number of students, beginners at study and graduates at CAS and UNI can be explained by the fact, that duration of study at the UNI is prolonged.

In the collecting period of 1975, nearly 20 000 surveying engineers worked with public administration and private industry (10). Today their number is slightly less. Out of this number, 82.3% were educated at CAS or its forerunners.

Reference	Year	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	Annual Average
Number of Students		2052	2172	2543	2900	3201	3309	3141	3183	3069	3476	2905
Number of Beginners in Study		784	872	922	974	985	908	792	900	884	1052	907
Number of Graduated Engineers		584	447	458	520	607	680	700	706	593	-*	508
Number of Graduated Foreign Engineers		6	5	6	1	3	2	3	2	3	-*	3,4
CAS HAMBURG												
Number of Students		228	234	240	284	306	309	296	307	341	448	299
Number of Beginners in Study		71	94	86	104	102	108	82	88	96	154	99
Number of Graduated Engineers		68	60	53	67	82	43	58	52	45	-*	59

* Data not yet available

Reference: H.M. Ahrens (1983), "Jahresbericht", ZfV

DATA RE. COLLEGES OF APPLIED SCIENCES (SURVEYING SCIENCES AND CARTOGRAPHY)

FIGURE 4

tion). The number of CAS graduates since 1977 demonstrates the high demand of certified engineers, specially in the field of professional practice (fig.2). It should be noted that during 1977 to 1981 more than 50% of all CAS students and 75% of all foreign students studying at CAS, were enlisted in engineering courses (fig.2). Only 4.4%, i.e. 450 of the block of 10 220 foreign students at

3. Organization

The organization of lecturing and education at CAS is determined by -greater compulsion in curriculum and subject matter,

- appropriate certificates of study and other details of examinations,
- education preferably in small groups (seminar form),
- special accentuation on practice during education,
- longer lecture hours and higher obligation for enrollment,
- consideration of certain subjects in respect to regional requirements,
- specific structure and qualification of faculty staff (11).

As 3-4 years of study should not be exceeded as a rule, the conciseness of contents as well as that of time in respect to curriculum and subject matters poses a problem. Apart from influence on the contents of study, the officially recommended length of study is important for

- administration
- guarantee of lectures
- determination and fixing of teaching capacity
- exact calculation of student figures for CAS's planning.

Therefore the legislator made it a rule that each special branch of the CAS had to establish its own reform committee. The reform committee for study is one of the most influential institutions at any CAS. On the one hand it has to change and complete lectures adjusting its contents to the latest developments in science and research as well as to new tendencies in profession. On the other hand it has to take into account certain measures which smoothen the impact of disciplinary pressure on the students in order to prevent scholarization of study.

The clear stress on application of science in practice induced several CAS's to include practical studies in their education. Some students at CAS's (including Hamburg) have to complete academically guided practical studies. As a rule, these practical studies take place after the basic study is completed, between the 4th and the 5th term and they last 20 weeks in general.

It is the goal of the main practical studies to introduce the student to the professional world of engineers by giving him training in a company or public administration office. The student is thus enabled to applicate his knowledge already acquired separately and theoretically during his study. At the same time he can profit from the insight into technical, organiza-

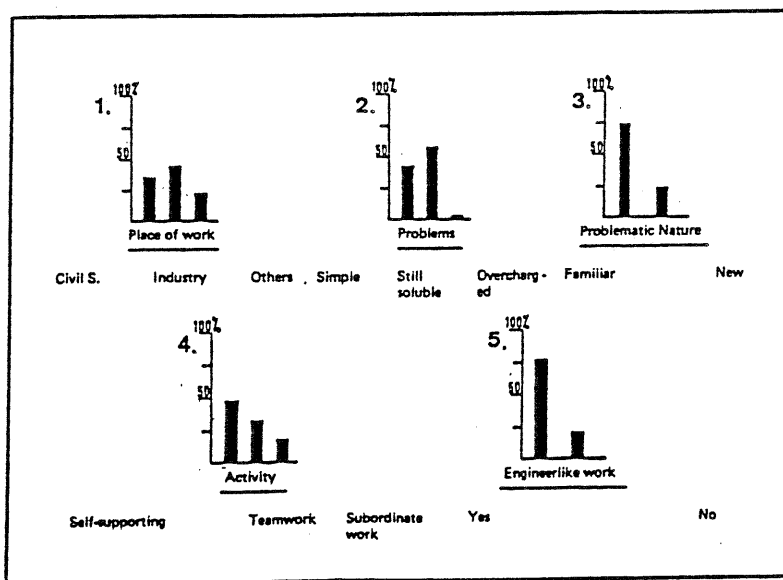


FIGURE 5

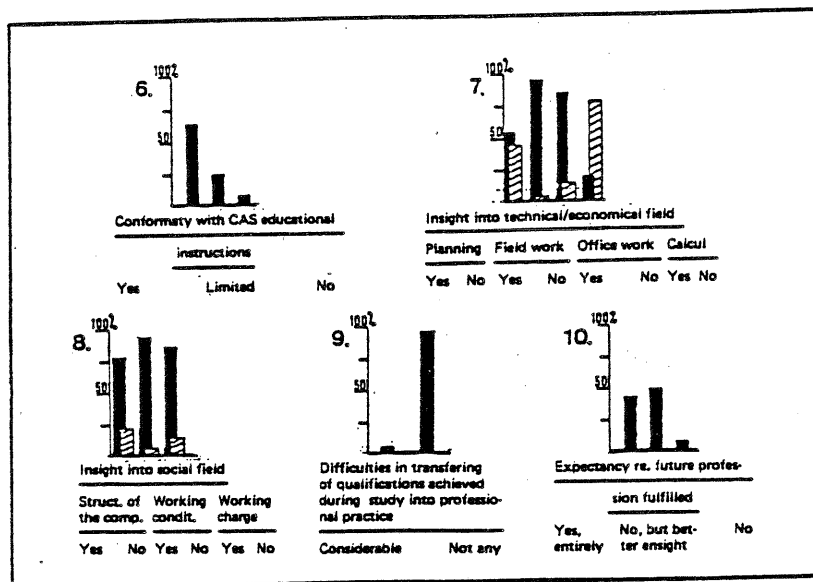


FIGURE 6

tional, and social problems of engineering practice (12).

In detail, the following goals are intended (including the already mentioned basic practical studies) to

- include practical problems into the contents of lectures,
- complete scientific education by experimenting and further illustrating of actual problems which present

themselves frequently in combination with special tasks from other fields,

- experience professional practice as a social sphere with its various economic and legal aspects,
- gain understanding as well as the knowledge of limits of theory,
- become acquainted with the solution of problems and assume responsibility at the very place of labour,
- make aware goals of both study and future profession by practical experience. (Thus motivation for studying will improve and choice of individual focal point of study is made easier),
- make uncertain ideas about the future assume concrete features (11).

During his practical studies the student is guided by a professor who observes the conformity of practical training and general directions for practical studies laid down by the CAS. He is apt to give support in case the given assignment presents a serious problem for the student.

An inquiry carried out among 163 students of surveying engineering at the CAS Hamburg, confirms the successful introduction of the course of practical work. Exemplary insight into activities and functions as well as answered questions in respect to training in practice may be observed from fig.5 and 6.

The generally positive rating of students in respect to the course of practical work counts for itself. In addition it should be noted, that students are fully prepared for professional practice by means of specified lectures and management courses.

After completing his practical studies the student has to decide - according to his preferences - in which of the main fields of surveying he wants to broaden his knowledge in particular. This might be either in

- Surveying Engineering
- Photogrammetry and Topography

-Cadastral Surveying, Mapping, Land Information System and Planning

The choice, however, does not confine the student's final decision for a career as a surveying engineer.

At the request of the German Society of Surveying, the Faculty of Surveying at the CAS Hamburg is at present establishing a course of intensified study in the field of Hydrography (Standards of Competence: Category A). The course probably starts in winter term 1984. With the realization of education in the field of Hydrography, the Faculty of Surveying at the CAS Hamburg will be the first university institution in Germany to offer this subject.

Intensified Studies	EN PH PL					
	1	2	3	4	5	6
1. Surveying Science	T	T	P	P	T	T
2. Instrumentation	T	P	P			
3. Surveying Calculations	T	T	T	T	T	T
4. Data Processing	T	T	T	T		
5. Mathematics	T	T	T	T		
6. Physics	T	T	P			
7. Juris Prudence and Admin.	T	T	T			
8. Social Geography	T	T	V			
9. Geometry	(P)				(P)	
10. Topography					P	
11. Photogrammetry			P	TP		
12. Cadastral Surveying, Mapping and Land Information			T	T		T
13. Land Reform			T	T		T
14. Planning, Building Land Regg port. and Boundary Adjustm.			T	T		(V) T
15. Earthwork and Urban Under-ground Constructions			T	T		
16. Road Construction						
17. Rural Road Works				V	V	V
18. Rural Hydraulic Engin.					V	
19. Cartography			T	T		
20. Reproducing Methods			V			
21. Geology						
22. Geomorphology					(V)	
23. Engineering, Surveying				P	P	
24. Least Squares Adjustment				T		
25. Photogr. for Eng., Surveying				P	P	
26. Astron. Position Finding				P	P	
27. Geophysics for Engineering				P		
28. Photogr. for Surveying					P	TP

Intensified Studies	EN PH PL					
	1	2	3	4	5	6
29. Town Planning and Regional Planning				T	T	T
30. Photogrammetry for Planners				(V)	(V)	(V)
31. Geodetic Seminar				(V)	(V)	(V)
32. Votation of Obligatory Subjects				I	I	I
33. Thesis						
Total	4	10	9	9	8	4
	7	5	7	5	7	5

EN = Engineering, Surveying
PH = Photogrammetry
PL = Planning, Cadastral Surveying and Land Information

T = Test Paper
P = Practical Studies
V = Test Paper/Practical Studies/Report
I = Thesis

EFFICIENCY CATALOGUE, CAS HAMBURG

FIGURE 7

Fig.7 demonstrates the scheme of study of the Faculty of Surveying at the CAS Hamburg as well as a catalogue of efficiency which can be considered a convincing proof of practice-orientated education (fig.7). It should be noted that as far as practice-relevant subjects are concerned, everyday assignments are put before the student in close co-operation of administration and engineering companies. The latter acting as "clients" of the student.

The closing test is a composition of oral and written examination, covering both general theory and the student's special field (after his own choice).

The thesis has to be produced during the 2nd period of study. Thus certifying the student's ability, to solve professional problems by application of scientific methods and knowledge in compliance with all aspects of his subject.

Nearness to practice, however, does not indicate remoteness from theory (13). Lectures on theory are delivered to larger numbers of students. Small groups are preferred for work on subjects related to practice. This means a mutual advanta-

- geous relationship of professor and student, providing
- intensive preparation of work, while carrying out practical exercise, reports, etc.,
 - optimal care while performing practical exercises with the general goal of stimulating practice orientated skills of students,
 - easier achievement of exemplary studies and simulation of practice,
 - thorough discussion, resulting in a prompt feedback between teacher and student.

4. Relations of the CAS to Developing Countries

4.5% out of a total of 251 400 students at CAS during winter term 82/83 were foreigners. According to the university law, the capacity of the CAS, however, extends to a full 8%. This illustrates that the potential offered to foreign students has by far not been exhausted. Quite on the contrary, the quota of foreign students, who took up surveying has been lamentably low. From 1972 to 1982 only 47 foreign students graduated in this field.

Before measures in respect to possible advance of attraction of the CAS are put up for discussion, likely reasons for the under-representation of foreign students in the field of surveying engineering and not only there shall be given below:

- Many countries did not yet realize, that a highly efficient personal of surveying engineers is indispensable at any phase of development and construction of infrastructure (14).
- No analyses of demand for qualified engineers exists, which shows realistic figures.
- It must be noted, that in the field of surveying engineering there is a difference between the German curriculum and goal of education and that of Developing Countries. So many foreign students feel that they are not educated in accordance to the special needs of their countries.
- It cannot be denied that there are difficulties in regard to proficiency of language on both sides. Because of this, contacts between possible partners do not realize, and the readiness to study in the FRG is low. In addition, the conversion of the acquired subject-matter into the language of experts (mostly English) after home coming, provides some difficulties.
- Many are suspecting difficulties in respect to their social, cultural, political, and family re-integration. Lack of experience in practice, combined with ignorance about the eligibility of german qualification on the local job market, motivates the foreign student to stay out.
- Absence of adequate continued education at home possibly results in dramatic drop of up-to-date knowledge, thus making a study abroad rather questionable.
- 13 years of existence of the CAS were apparently not sufficient to make the CAS generally known in accordance with its significance to the german educational system

and its useful contribution to technology transfer (13).

According to CAS education politics, engineers in Developing Countries should be able to master the following major tasks:

- develop competence in management and charge of already existing enterprises and services, their maintenance as well as repair of machines and installations,
- procure information and experience which enables to draw parallels to alternative processing and to select adequately among the technical, economical and social criteria available,
- develop analytical, technical, and educational faculties for modification and adaptation of imported technology and depict jobs and operations for educational purposes for technicians and experts,
- dispose of sufficient scientific qualifications to identify and analyze requirements in his special field, research for solutions and methods for further development and better utilization of local resources,
- excel in qualifications, to adjust work to political, economical, and social goals of the country, especially by offering valuable guidance to government and industry management alike (15).

Sole study in the field of research and development has little importance for engineers in Developing Countries.

Undoubtedly university education in Industry Nations generally does not provide special preparatory training for engineers in developing countries. According to experts foreign students are thus endangered to suffer from mis-orientation and cultural alienation which might in its contents outweigh the personal advantage believed to be linked to study abroad.

Partnership between university institutions may contribute just as little to the education of development engineers, if indispensable discussion on particular preconditions which shall be specified later on, is not started. Because of the reasons offered before and the distinct demand for a change in the relation of theory to practice in favor of a more practice-orientated mediation of knowledge, universities in developing countries might find themselves in an intricate position. On the one side they feel obliged to academically substantiated standards which are based on traditional conceptions of university education. On the other hand they are urged to consider urgent development strategies of their respective countries.

This is where the CAS is called upon to stand its ground, offering a valuable choice providing practice-orientated education and a reasonably limited time of study.

In the field of surveying engineering the reasons for a possible co-operation between CAS's and developing countries could be founded by:

- planning, development, and introduction of additional courses of intensified studies, specially orientated by problems and conditions of developing countries. (These courses should also be open to German students),
- establishing a curriculum (interdisciplinary subjects should be included, if necessary) for the newly intro-

- duced course of intensified study in close co-operation with colleagues of Developing Countries,
- intensified exchange of professors between FRG and the countries of the Third World,
 - acquisition, administration, and cultivation of places for practical studies in the FRG as well as in the Third World. (The places for practical studies should be available to German and foreign students alike.)
 - counsel to private engineering-companies and public institutions in order to avoid differences which might result from the different approach to mediation of "Know-How" by university and CAS,
 - providing favorable conditions, both practically and economically, for the respective countries by offering a thesis exceeding the academic demand in favor of applicability in practice (Sandwich-Program).

Supporting measures such as:

- introduction of student counsellors who might be recruited among CAS professors who are familiar with problems of Developing Countries,
- offering of special lectures, preparatory to re-integration and adjustment of acquired knowledge to the local situation in Developing Countries,
- improvement of professional infra-structure of Developing Countries by launching projects meeting the countries specific requirements of local industry and administration,
- lecturing in English in order to prevent language problems should be adopted.

Institutions in the FRG which attend to promotion of foreign students as well as comparable organizations in Developing Countries should be encouraged to bestow more scholarships on students of surveying engineering.

In connection with this it should be referred to co-operation and transfer of technology already existing between the CAS Hamburg and local industries as well as the Portsmouth Polytechnic and the Polytechnic of the Southbank of London. Further partnership has been agreed upon with universities in Denmark, Poland, and the USA.

The Peoples Republic of China lately displayed a vivid interest to establish a great number of CAS on its territory.

Meanwhile a student from CAS Hamburg completed his practice term with the Governmental Road Construction Administration in Chile. His thesis will relate to the problems encountered in this country and he shall start working on his paper in situ.

A couple of foreign students, enrolled at the Faculty of Surveying Engineering of CAS Hamburg, also picked the subject for their theses among the problems proposed by their respective countries.

These arguments should start a discussion which might not lead to immediate results but on the long run provide realistic terms for practicable education, whose contents and process is not only orientated on the vocational training in Germany but meets the very requirements of Developing Countries.

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