What Were We Expecting? Analysing Expectations of German University Teachers of Study Beginners in Computer Science as Experienced by Students

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2022 IEEE German Education Conference (GeCon), 2022

IEEE Xplore: https://ieeexplore.ieee.org/document/9942748

DOI: 10.1109/GeCon55699.2022.9942748

What Were We Expecting? Analysing Expectations of German University Teachers of Study Beginners in Computer Science as Experienced by Students

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***Abstract*—We present a study about the expectations students in higher education perceived to be placed on them. The study includes higher education institutes all over Germany, distributed over the different types of private and public higher education institutes that exist in Germany. All students currently enrolled in a computer science or related study programme were targeted; we distributed the survey by identifying study coordinators for relevant study programmes, contacting them via email, and asking them to forward the study to their student body. We received 638 responses from students all over Germany in an approximately representative distribution by gender, Bundesland (German federal state) and type of institute. The study was split into four parts: general statistical questions, general skills, domain-specific bodies of knowledge, and areas where students and educators often report problems. To analyse the results, we define the concept of *agreement*, which is the quota of students which note the specific item to be expected or mostly expected, in comparison to all responses. In general, only soft skills were expected by teachers, with programming language being the only domain-specific body of knowledge students agreed on whether they were expected to know it. This is the same answer as found by a prior study. We found that there does not exist a singular problematic topic but rather that all areas were received to be somewhat problematic. However, female students experience more expectations and problematic topics from teachers than male students.**

***Index Terms*—Computer science education, educational institutions**

I. Introduction

In Germany, a high percentage of students starting their computer science degree will not finish it. The exact percentage varies by source and year but generally stays between 30% and 45% [1], [2], with the biggest reason for students dropping out of their study programme being the high performance requirements, especially at the beginning of the studies [1]. Since the prevention of drop-out is of emerging interest in the scientific area [3], this paper is looking into one possible source for the high performance requirements: high expectation of prior knowledge of university teachers. Our hypothesis for this is as follows: If teachers expect knowledge of students which are not fulfilled, then a lot of students might be overwhelmed by the content of their programme (especially at the beginning of their studies). Our assumption is not unheard of in the scientific community: At least for introductory computer science courses, it is suggested that too high expectations of teachers lead to the failure of students [4].

One might argue that the expectations of university teachers should be close to the knowledge required to pass the final school exams. There are, however, some problems that result from the school structure in Germany: After World War II, jurisdiction over schools/educational politics in Germany was transferred to the Bundesländer (federal states of Germany) [5]. Even organisations such as the *Kultusministerkonferenz* (*KMK* for short), where all relevant ministers of the different Bundesländer meet, can only give non-binding recommendations [5]. This means that, even though some recommendations exists (such as from the KMK [6] or the *Gesellschaft für Informatik*[1] [7]), there is no commonly agreed standard of what a pupil should be capable of doing after finishing the final exams (or even if computer science is mandatory in school at all).

A first study on this topic was done by Bender et al. [8]. In their study, they sent a questionnaire to university teachers in Germany and concluded that there are no computer science-related expectations by university teachers (both professors and other teachers). However, since they only interviewed university teachers, there might be a bias that either those teachers were not aware of their expectations or they unconsciously underreported their biases.

In an attempt to both validate the study by Bender et al. [8] and to find those hidden biases, we reproduced the study but sent it to a different target group: university students. While we

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[1] https://gi.de/

are aware that this group might have a different bias and might overreport the experienced expectations of their teachers, we hope that by comparing both studies we might get a good overview over the real expectations university teachers have.

II. Related Work

A good overview over reasons for drop-outs in Germany is given by Neugebauer et al. [3] as well as Behr et al. [9], although their publications focuses more on the general reasons for drop-outs of university programmes.

While the topic of expectations in computer science programmes is not new, a lot of focus has been on the expectations students have [10]–[13]. While the point of view of students is also important, we want to focus on the expectations teachers have.

Our study is based on the work of Bender et al. [8] in an attempt to eliminate possible biases and to validate their findings (only general skills are expected, no prior computer science related knowledge is expected of students).

A different approach to this topic, although only for introductory programming courses and focussed on the outcome of those courses, was taken by Becker and Fitzpatrick [14]. They analysed the syllabi of around 900 institutions to extract the expectations of teachers. A similar study was done by Groeneveld et al. [15], where they focussed on the non-technical expectations (i.e. soft skills).

III. Study Design

Our goal was to find evidence (or lack thereof) supporting the hypothesis of there being high perceived expectations from teachers by students of computer science. To answer that question, we conducted an online questionnaire. We used the questionnaire of Bender et al. [8] with only minor changes to both include the newly found items by Bender et al. while also ensuring comparability.

Since we could not contact students all over Germany directly, we chose to contact them through their educational institute (e.g. university) and ask them via an online survey. We selected educational institutes to contact for the survey based on which institute offered a computer science Bachelor's programme or a closely related programme on `studienwahl.de`[2] to make sure we were able to identify all institutes with relevant programmes. We included both publicly and privately funded institutions in our search. For all found study programmes, we tried to identify study advisors or study programme managers and contacted those via email requesting them to relay the survey to their student body. Whenever we could not find a study advisor / programme manager, we contacted the institution via a general purpose email address identified on their website. A total of 153 institutes all over Germany were contacted this way.

[2]a web platform for aspiring students in Germany to inform themselves about study programmes that might interest them and apply to universities offered as an official service by the German ministry for employment (Bundesagentur für Arbeit) and the German foundation for university admittance (Hochschulstart Stiftung für Hochschulzulassung). Unfortunately, the list of study programmes has been moved as of the publication date of this paper.

The survey was conducted in German. It was split into four parts:

1) general statistical data to use for comparison of groups (gender, Bundesland, type of institute, study programme type, current semester),
2) general skills (e.g. logical thinking, general interest in the discipline, analytical skills),
3) discipline-specific bodies of knowledge (e.g. handling of different operating systems, database use, formal languages, programming skills), and
4) areas in which students perceived notable difficulties and were thus perceived as problematic.

Except for the first part, all parts measured a set of skills/bodies of knowledge identified by [8] on 5-point Likert scales and offered an option for the participants to add skills not listed in the survey into free text areas. Those free text areas were then inductively coded [16] by two persons.

IV. Results

The study was conducted during the month of December 2021. In total we received 638 responses. If we look at the results, we can compare this to the distribution of students in Germany:

- Around 69% of participants identified as male, 25% as female and 2% as other gender. Based on this, our rate of females is about 5% higher than the rate of females in computer science programmes in Germany based on [17] (based on 2020/21).
- The distribution of the Bundesländer (federal states of Germany) the participants studied in can be seen in Tab. I. If we compare the distribution to [18], we see that we have an overrepresentation of students in Hamburg (possibly due to both authors having studied in Hamburg) and Hessen as well as an underrepresentation of students in Rheinland-Pfalz. Other than that, all Bundesländer in our study are within a range of five percentage points compared to [18].
- If we look at the type of institution, 47% reported that they study at a university, 17% at a technical university, 32% at universities of applied sciences and 5% at other institutes. Compared to [19], we have a slightly higher rate of students coming from universities/technical universities than the average in Germany and a slightly lower rate of students coming from universities of applied sciences.

If we look at this, we can see that there are some minor differences between our participants and the distribution of students in Germany. Since those differences are rather small, we would argue that our study is still representative for Germany.

In Fig. 1 we can see the distribution of participants by their semester of study. We see a stark contrast between odd and even semester numbers, which can be explained with the fact that most institutes in Germany offer computer science programmes starting only in the winter term, while only a few

TABLE I
NUMBER OF RESPONDENTS BY BUNDESLAND (FEDERAL STATE)

Bundesland	Num. of Respondents	Percentage
Baden-Württemberg	97	0.15
Bayern	106	0.17
Berlin	23	0.04
Brandenburg	0	0.00
Bremen	0	0.00
Hamburg	71	0.11
Hessen	78	0.12
Mecklenburg-Vorpommern	20	0.03
Niedersachsen	30	0.05
Nordrhein-Westfalen	160	0.25
Rheinland-Pfalz	2	0.00
Saarland	0	0.00
Sachsen	19	0.03
Sachsen-Anhalt	1	0.00
Schleswig-Holstein	1	0.00
Thüringen	30	0.05
Outside Of Germany	0	0.00
No Answer	0	0.00

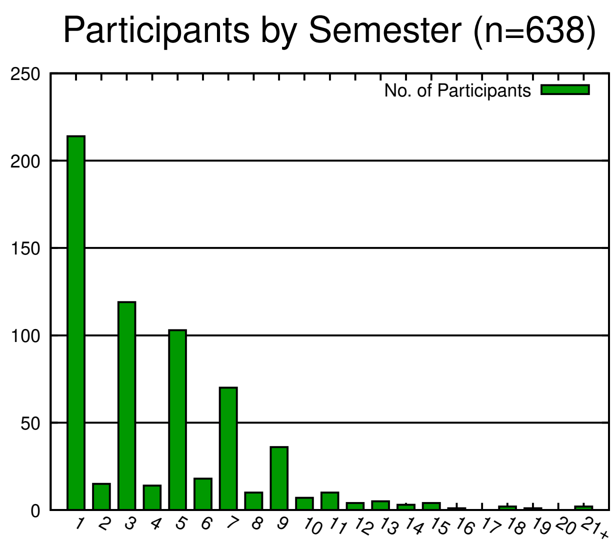

Fig. 1. Distribution of Participants by Semester ($n = 638$). Two responses were grouped as outliers (one being semester 45 and one semester 48).

offer a start to the summer term. Two responses were grouped as outliers, these were from students in their 45th and 48th semester, respectively.

Fig. 2 displays the aggregated results of the question group concerning general skills. We define *agreement* as *the quota of participants that rated this competency to be perceived as expected or mostly expected* (analogous *disagreement*). The first observation to make is that several of the surveyed skills seem to be more or less universally applicable, i.e. the first 6 skills all display an agreement of over 80%, with *Logical Thinking* leading the list with almost 90.5% agreement. 20 out of 27 measured general skills hold at least majority agreement ($\geq 50\%$). 14 out of 27 measured general skills hold a 2/3 agreement, the same number as a 3/4 agreement.

The second observation is that several skills seem to be divisive amongst the participants, starting with *Eye for Detail*, which reaches an agreement level of only just about 50%. The skills with the least agreement are *Interdisciplinarity*, *Visualizing Results*, *Social Skills*, and on last place *Physics/Engineering*, all of which show an agreement of less than 33%. Only two general skills, *Visualizing Results* and *Physics/Engineering*, which are also two of the four general skills with the least agreement, display majority disagreement.

Fig. 3 displays the perceived expectations concerning domain-specific skills, again sorted by agreement. No bodies of knowledge reach a 2/3 agreement, and the only body of knowledge to reach a majority agreement is *Software*, or as Bender et. al. define it "Nutzen handelsüblicher Software" [8] (use of commercially available software) with an agreement of $\approx 60\%$. 9 out of 19 domain-specific bodies of knowledge covered by the survey do not even reach a 1/4 agreement. Furthermore, only four out of 19 bodies of knowledge do not reach majority disagreement, i.e. do not have a majority of participants that note the specific item to not be expected. These items are *Software*, *Set Theory*, *Logarithms*, and *Reading Functional Expressions*. Another four out of 19 items observe a 3/4 disagreement, i.e. $\geq 75\%$ of participants note these items to be either not or mostly not expected. These items are *Computer Networks*, *Databases*, *Automata Theory*, and *Data Analysis Languages*.

Fig. 4 displays the results for the areas in which students perceived notable difficulties, however students do not agree on any topic to be difficult. Out of 19 items, 8 reached majority disagreement; these are *Operating Systems*, *Computer Architecture*, *Markup Languages*, *Databases*, *Data Analysis Languages*, *Binary Numbers*, *Informatics in Society*, and *Software*. The item which reached the largest agreement with 49.8% represents the use of *Programming Languages*. Five items reached less than 1/4 agreement: *Databases*, *Data Analysis Languages*, *Binary Numbers*, *Informatics in Society*, and *Software*. On the contrary, *Software* reaches by far the largest disagreement, being the only item with a disagreement of over 80%.

For all of the three areas above, we can compare the experience of male and female students to see whether gender is an important factor here (since the rate of other gender is small, a comparison was not possible there). We can see that for all areas where a significant difference was observed (two-tailed t-test: $p < 0.05$), female students experience expectations from teachers more (general skills: *Media Skills*, *Visualizing Results*; discipline-specific skills: *Software*, *Reading Formal Expressions*, *Set Theory*, *Producing Formal Expressions*, *Computer Architecture*, *Formal Languages*, *Informatics in Society*) and perceive topics more problematic (*Programming Languages*, *Operating Systems*, *Computer Networks*, *Computer Architecture*, *Markup Languages*).

In addition to the measurement of the items using a Likert scale, parts 2-4 of the survey offered a free-text entry field for participants to add points they felt were missing. Two different coders evaluated these responses independently. Tab. II displays the frequency of added points for the general skills part of the survey. It can be seen that several participants

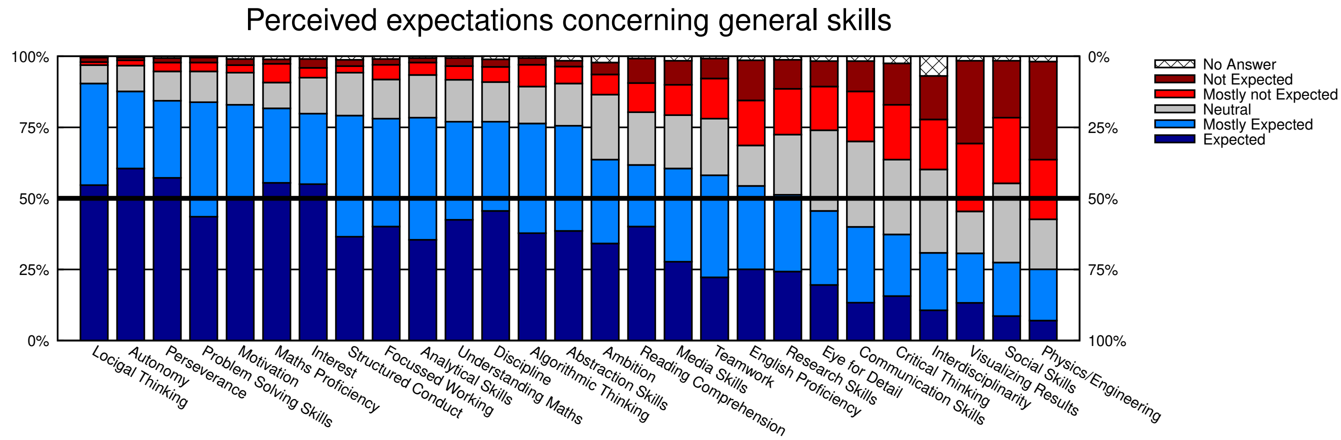

Fig. 2. Aggregation of perceived expected general skills ($n = 638$), sorted by Agreement amongst participants. We define Agreement as the percentage of students who perceive a given competency as either expected or mostly expected.

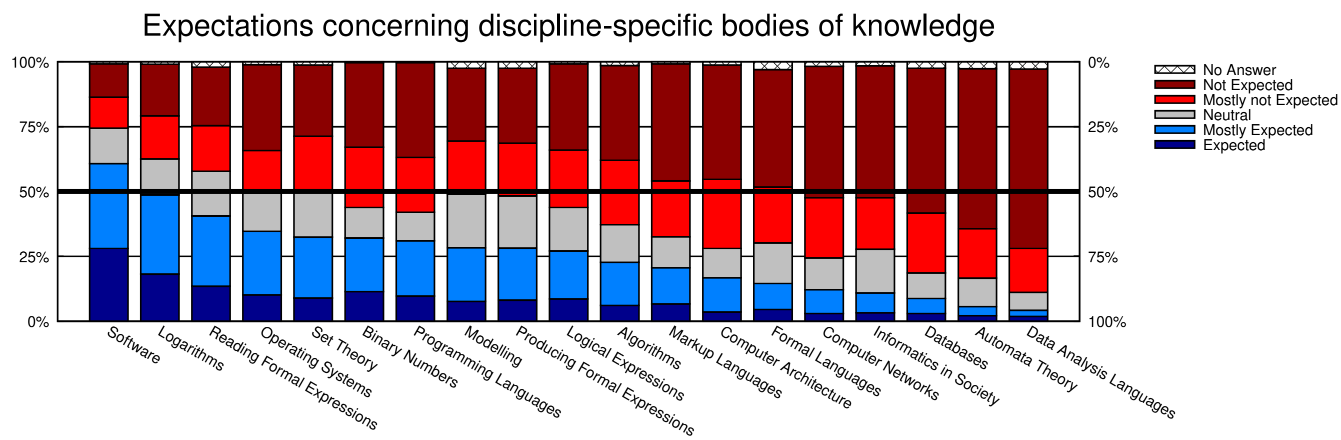

Fig. 3. Aggregation of perceived expected domain-specific skills ($n = 638$), sorted by Agreement amongst participants.

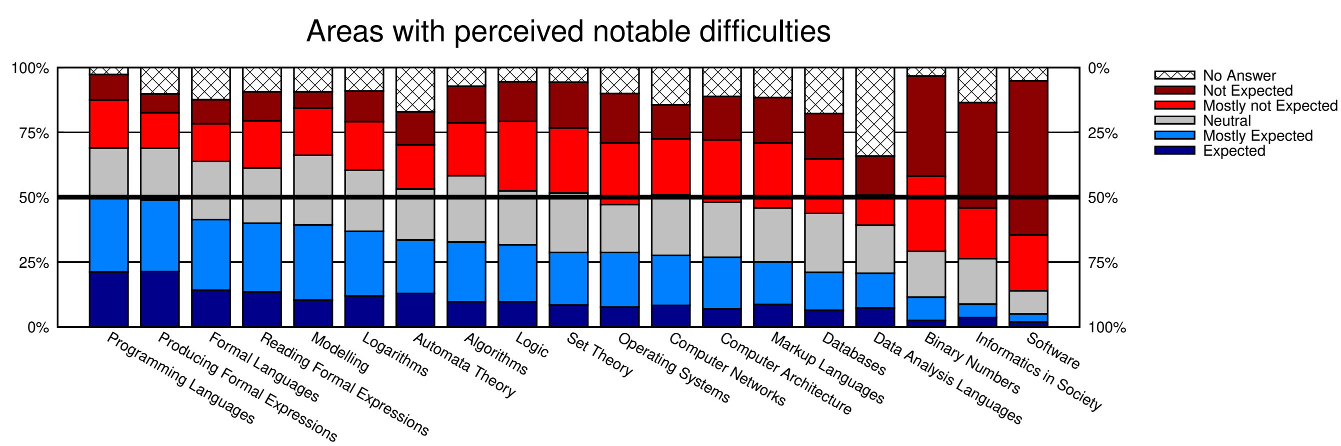

Fig. 4. Aggregation of areas in which students perceived notable difficulties ($n = 638$), sorted by Agreement amongst participants.

TABLE II
FURTHER EXPECTATIONS: CODE FREQUENCIES FOUND IN THE FREE TEXT QUESTIONS. THE RESULTS WERE CODED BY TWO DIFFERENT CODERS.

Code	Coder 1	Coder 2
Mathematics	17	17
Programming	16	17
Resilience	20	12
Self-Organisation	15	7
Readiness of Mind	6	4
Time Management	6	4
Basic Knowledge of Computer Science	4	5
Motivation	4	5
Ability to Work Independently	7	2
Handling Bureaucracy	5	4
Working with Formal Notation	4	5
Ability to Adapt	6	2
Electrical Engineering	3	2
Power of Concentration	2	2
Working with Common Software	2	2
Handle Hierarchies	1	1
Intelligence	1	1
Self-Reflection	1	1
Methodical Approach	0	1

TABLE III
PROBLEMATIC AREAS: CODE FREQUENCIES FOUND IN THE FREE TEXT QUESTIONS. THE RESULTS WERE CODED BY TWO DIFFERENT CODERS.

Code	Coder 1	Coder 2
Mathematics	15	27
Programming	15	27
Working with Formal Notation	1	8
Electrical Engineering	3	4
Theoretical Computer Science	2	5
Physics	1	3
Algorithms	2	1
Data Structures	0	1

felt the need to express *Mathematics* as an expected skill in addition to it being mapped in two items. Further topics several participants felt the need to add as perceived expectations were *Programming* skills, *Resilience*, and *Self-Organisation*. Skills mentioned in these categories were use of APIs, resilience in dealing with bureaucracy, or self management to keep up with deadlines, amongst others. Several other perceived expected skills can be seen in Tab. II, clustered into categories.

Tab. III displays the code frequencies for responses that were considered to point to problematic expectations. Again, *mathematics* and *programming* stand out with many mentions. Examples mention the steep learning curve for maths or the mismatch in prior experience concerning programming as sources for problems, amongst others.

Over all free-text questions, we received 3 answers which we categorized as 'missing practical relevance in the study programme'. The answers critiqued courses where it was non-obvious how they related to the desired degree or how their content would relate to practical applications. Moreover, for 6 answers we couldn't find an overarching category (miscellaneous). These can be summarized as overburdening the students, criticising organizational aspects, or mismatching perceived and communicated requirements.

V. DISCUSSION

If we look at our results, we must notice that almost all soft skills were expected of students. At the same time, almost no domain-specific bodies of knowledge were expected, if there is any expectation it is more on general-purpose knowledge such as how to use computers and maths knowledge. Keeping in mind that computer science is not mandatory in German schools and that the content of computer science classes might vary between the different Bundesländer (federal states of Germany), this pretty much is in line with what one might expect. Based on this we can conclude that wrong expectations are most likely not a problem why students abort their study programme. It is, however, important to note that mathematics and programming were mentioned a couple of times in free-text questions as expected by teachers.

We can also compare our results to the prior study of Bender et al. [8], who asked teachers instead of students. Comparing both in terms of soft skill expectation as well as body of knowledge expectation, we get quite similar results. Since both - the view of the teachers as well as the experience of the students - match, we can be confident that these findings do in fact reflect the reality on higher education institutes. Still, there might be some bias in the study since we were only able to record data from students who have not yet aborted their study programme (who would have been the most important ones) and were motivated enough to participate in the online survey. Thus, we might still have some kind of selection bias.

A special look should be taken into the areas where students perceive problems. Based on our data, we cannot identify a single area (or a couple of areas) which is especially hard for students. Instead, almost all areas had more than a quarter of students who had problems in that area. At the same time, there is no area where a majority of students have problems (maybe except programming languages and producing formal expressions, but even those items did not reach half of the students). This is in disagreement to Bender et al. [8], where university teachers actually found eight areas where students might have problems: producing formal expressions, modelling, reading formal expressions, formal languages, logic, automata theory, programming languages and logarithms. Based on this, we can conclude the following:

- University teachers have a much more critical view on where students struggle compared to the students themselves.
- It seems there is not a singular area where students struggle. Instead, computer science as a whole seems to be difficult to students.

Since most studies focussed on problems of a single factor or single course [20], this is quite surprising. Based on this, it would be useful to focus research more on the topic of higher education of computer science itself than on specific courses.

It is important to note that our data shows that female students experience expectations of teachers as well as the problematic areas stronger. This is important since the rate of females enrolled in computer science programmes in Germany is lower compared to males (see [17]). Unfortunately, our data can not show the reasons for this.

VI. Summary & Future Work

In this paper, we presented a study where we asked German computer science students about the expectations that were placed on them during the beginning of their study by university teachers. The study revealed that only soft skills are expected by university teachers as well as only more general bodies of knowledge (such as using a computer and mathematics) in comparison to computer science specific bodies of knowledge. These results fit well with the structure of computer science teaching at German schools, since computer science neither being mandatory nor having a unified curriculum across all of Germany. Our results also match those of a prior study [8]. This might suggest that wrong expectations are not a problem in Germany's higher education system. It is worth to keep in mind that female students experience higher expectations from teachers than male students as well as experience problematic areas more strongly, which might be one factor in the comparable low rate of female students in computer science.

However, since we found out that there seems to be no singular problematic course for students, it might be necessary that future research on computer science education for higher education takes more of a holistic approach. Research akin to Salguero et al. [20] would also help in Germany, since they focussed on such a holistic approach and found that students in the United States of America often struggle with multiple problems. Reproducing something like that for Germany might be interesting. At the same time, we suggest to look at the curricula at universities in total to find out whether we overload students with knowledge teaching (as suggested in [4]).

Acknowledgements

The qualitative analysis of the free text responses was done using the QualCoder software [21]. All students gave their informed consent for the participation in the study. The study was acknowledged by the local ethics committee.

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