

School of Chemical Technology

Scientific Advisory Report 2016

Scientific Advisory Board:

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1. Summary and Key Recommendations.

The Scientific Advisory Board (SAB) visited the School of Chemical Technology (CHEM) for the third time from November 14-16 2016. The meeting was well prepared from the school and the departments. The meeting was efficient with open discussions. We thank the Dean Janne Laine and Ms Pönni Raili for the excellent arrangements and support. The Dean has done excellent work in creating consensus for the strategic changes and for the successful start of the implementation of an ambitious strategy plan. We recommend that the Dean gets the opportunity to benchmark these plans via visits to leading Universities.

The visit was arranged in the middle of drastic changes with reduced funding and big reorganization of CHEM. We found that CHEM has improved significantly since our last visit in 2014. Many of our recommendations have been followed. CHEM is on the right track as reflected by several indicators. However, CHEM still faces a big challenge to improve its international ranking. We think that the main issue is to improve the scientific excellence in particular by stronger and planned activities for internationalization. There is also a need for improvements at school and department level in specific areas.

The departments have gone through severe budget cuts and reorganization and the SAB recommends that **the reorganization is now halted** and the departments **intensively focus on achieving excellence**. Although the SAB observed a move towards international excellence in several departments, not all departments have yet achieved the excellence level envisaged in Aalto's strategic plan. To improve excellence, the SAB recommends as a first objective that **the School further refines a clear vision / mission statement for the next 5 years**. Likewise, **the individual departments need to articulate a clear vision / mission statement that unites the different research groups** and is supported by all professors. In formulating these mission statements, thought should be given to **attractive branding**. The SAB believes that this mission statement will **enhance synergy between the research groups** and, hence, will promote bottom-up collaboration among professors within a department and among professors between departments; indeed, in addition to excellent people and leveraging infrastructure, multidisciplinary research enhances chances for top publications. Likewise, collaborations are encouraged at the School and University levels. The SAB recommends that, in addition to the platforms, **new instruments are created that facilitate such collaborative projects**. In addition, research excellence is in large part correlated with **research focus and international visibility**.

To further promote research excellence at the **University level**, the SAB recommends that:

1. A clear strategic plan for internationalization is developed.
2. A fund for game changing investments is established.
3. Support groups for commercialization are strengthened.

To further promote research excellence at the **School level**, the SAB recommends that:

1. A clear mechanism is put in place to recruit and retain the best students and staff.
2. A clear strategic plan for internationalization is developed.
3. The School increases its visibility by organizing a high level international meeting under the title 'Bioeconomy' (annually or biannually), where top scientists are invited (paid) for seminars and where Aalto group leaders present their work as well. These meetings can be financially supported by industry. As part of the meeting, the invited speakers visit the department and have organized discussions with the group leaders. This should increase collaborative projects.
4. More events are organized to increase visibility of Aalto's research, e.g. pilot plant visits.
5. Further efforts are made to create a stimulating and proud working atmosphere at School and Departmental levels.
6. A high-level industry contact program is created.
7. Further efforts are made to improve the School's postgraduate training.

To further promote research excellence at the **Department level**, the SAB recommends that:

1. Departments make sure that sufficient critical mass is given to the various research topics. A thin spread of the research efforts almost certainly guarantees failure.
2. Group leaders improve their visibility by oral presentations at international meetings. This will increase applications from international PhDs, more requests for participation in international (e.g. H2020) projects, better positioning in the field, etc.
3. Group leaders actively identify the best teams worldwide with complementary expertise and that they initiate collaborations with these teams. This will lead to higher quality publications, exchange of international students, and enlargement of the scientific network.
4. The School/Departments regularly organize a Summer school in their field that attracts international PhD students that network with the Aalto PhD students. The Summer school provides a range of lectures, visits to the department, and social network activities.
5. Individual high-level peers are actively invited for a two day (or *week*) visit (e.g. paid by industry) to give a seminar, advise on projects and discuss potential collaboration.
6. The professors from departments that did not yet reach Aalto's expected excellence level, have a meeting to discuss the adoption of best practices from other departments.
7. Excellence is rewarded by small, but motivating initiatives, such as:
 - a. whenever a top paper has been published, organize a drink and/or issue a press release.
 - b. reward the best papers of the year, or papers above a given impact factor by, for example, a conference meeting travel award to the principal author.

2 Development and Potential

Overall, there has been a dedicated effort to respond to past SAB review comments, which is reflected in the success of the students, new faculty/established faculty and research departments. Furthermore, the faculty and administration both need to be acknowledged for these successes having been accomplished despite the financial difficulties brought about by changes in certain Finnish funding agencies. These changes certainly highlight the need to continue an emphasis on translational, multi-disciplinary research teams and departments with strong international partnerships. The latter can be a natural vehicle for future EU grants, and industry funded projects. The faculty should explore industry focused continuing educational programs which can build excellent long term partnerships with industry.

Clearly, excellence in engineering is dependent on excellence in students, faculty and research infrastructure. Aalto seems to have a reasonable path-forward on these issues, but these days very few institutions can maintain leadership in a variety of analytical/pilot-plant/computational facilities (i.e., high cost research infrastructure). Certainly, VTT provides a partial solution to this challenge, but Aalto needs to form additional strategic partnerships with leading research institutions in Europe, North/South America and the Far East to help develop new science/engineering accomplishments using this research infrastructure. As Aalto continues to build a strong presence in sustainable development, faculty and students will need exposure to LCA issues, which were not addressed in the current presentations. This may be one area where natural national/international partnerships could be developed.

The integration of the Arts with Science and Engineering seems to have been met with varying degrees of successful and administrative clarification of this issue would be beneficial to faculty. Given, the significant management changes implemented by Aalto in the last few years the administration now needs to champion these changes and provide a certain degree of stability and certainty to allow faculty and students to grow into these new units and strategies and contribute to Aalto's relatively new vision/mission. Hence, concerns were expressed for the need to maintain the quality of mid-sized capital cost research equipment. Finally, as much as the faculty and administration have been successful in recruiting new staff, the same effort and discussions need to be pursued for retention of successful faculty members.

3. Infrastructure

We support the CHEM initiative for planned investments through the "Bioeconomy infrastructure" followed by the "Rawmaterials infrastructure". We agree that the management (prioritisation) should take place in the steering committee at school level and that the operation and maintenance is the responsibility of the departments housing the equipment. Irrespective of this, there is a great need for small investments in the departments. Also, (as mentioned in previous SAB reports) the university should create a fund for groundbreaking investments.

It is evident that this coordination of investments should be accompanied by more collaborative projects within the departments, between departments and between schools and other universities and VTT. The platform model is a good initiative, but more mechanisms should be developed to implement and finance these projects. Multidisciplinarity should be strongly encouraged, however, not imposed if international excellence is secured in a single field.

4. Innovation and Impact

Aalto and in particular CHEM has a fine record for collaboration with industry. This has been funded mainly by TEKES. As this funding source has declined substantially, CHEM is looking for new ways to fund larger projects through strategic alliances. We support this approach. Industry must find this collaboration attractive enough to finance the main part of the collaboration. Visits to the companies may be supplemented with creation of an "Industrial Contact Forum" (or Industrial Affiliates' Program) with a small membership fee. This would include an annual prestigious event at Aalto at which CHEM presents its results and competencies. It may also act as a "window to science" by informing on general trends world wide. The companies may also make presentations. The strategic alliances should stress the split of roles. Industry solves "how" and CHEM "why" with emphasis on basic research. The 65/25/10 model described earlier may be part of the agreement, which should also include clear and fair IPR rules. Industry may also support CHEM by financing visiting peers and even full professor chairs.

The university should encourage government to introduce a new scheme for industry/university collaboration, for instance, with a split funding company/institute/ministry of 25/25/50, which is allowable within EU.

SAB notes that a number of invention disclosures have been made and there are several patents. However, invention alone is not innovation. The university should strengthen support groups (incl. seed funding) for commercialization.

CHEM should continue to show examples of new ideas resulting from multidisciplinary projects. ARTS is fine, but there is potential for much more.

A number of outreach activities were presented and showed strong participation from schools. The interaction with high school teachers is strongly supported. This could have an immense social impact.

5. Departments

General Comments

The departments have reorganized and captured Aalto's research vision and all have been successful, to some extent, in recruiting new faculty and developing new research initiatives. The requirement for 4 publications/PhD in 4 years is a reasonable goal but certainly the emphasis should be on the quality of the publications and not the number of publications. The same research parameters also need to be instilled in the postdoctoral research fellows. One of the best long-term measures to recruit excellent students and postdoctoral fellows is a strong record of high quality, impactful publications, which will contribute to Aalto's research mission. Other elements that will contribute to this goal are a resourceful/impactful educational web-presence, international/national partnerships, invited undergraduate research experiences, student exchange programs and financial incentives for top students (i.e. scholarships).

The SAB recommends that each school hold a retreat and engage international partners to answer the question "What are the future research opportunities and development needs of Finland and the globe, in their respective fields, in 20 years from now. Next, how will the respective schools begin to address these needs now." This document could be used for future faculty recruitment efforts and strategic seed projects. Finally, the committee strongly supports that the departments acknowledge impactful papers,

best-paper of the year, research-breakthroughs, best student poster/presentation. This can involve a variety of mechanisms including acknowledging success with press/web announcements, establishing departmental annual awards, etc. The departments need to develop strategies that contribute to faculty retention of “research stars”. Other universities accomplish this by providing financial rewards to students (i.e., best paper/thesis of the year), providing relief from teaching, sabbatical leave, seed funding to explore new research avenues, relief of some bench fees and, certainly, an aggressive departmental program to nominate faculty for national/international awards. Given current successes and future needs, the Department chairs and faculty need to develop a set of “Best Practices” for (i) faculty recruitment; (ii) graduate student recruitment; and (iii) retention of faculty “stars”.

The Department of Forest Products Technology (FTP)

The Department’s research focus and activities capture the exciting potential for Aalto’s Schools/Departments to have a significant translational impact on science and engineering. The Department has continued to grow in size, funding and international stature since the last review period, leveraging the department’s current core competences and bringing in new competencies to the department and strengthening its contribution to national and international biorefining efforts.

In terms of funding, the department needs to help influence future alternatives to TEKES funding, initiate strategic partnerships for future EU programs, and continue to build bridges to Scandinavia/international Forest Product companies seeking expertise in biorefining. FTP needs to pursue long term opportunities to have industry/private citizens to fund student scholarships, infrastructure, and/or faculty chairs. The department should begin to publish on the web standardized experimental procedure, such that the FTP web site becomes the place for select biorefining procedures, much the same that US National Renewable Energy Laboratory’s procedures on biomass characterization have become the pre-eminent resource for these procedures. Greater concern and practice of Life Cycle Analysis (LCA) needs to be incorporated into FTP research activities, which could be accomplished internally or in partnership with other organizations.

Using plant (green) biotechnology (genetic engineering), the composition and structure of the plant raw material can be altered. These alterations may alter/improve/widen the chemical reactivity of the biomass towards the development of new products. Plant biotechnology is currently not integrated into the research program of the Department of Biotechnology and Chemical Technology. The SAB realizes that the University of Helsinki is specialized in plant biotechnology and that efforts should not be duplicated at Aalto but rather efforts should be made to collaborate. Because of the reorganization at the University of Helsinki, discussions on possible joint projects have not happened yet or have been postponed. It is well possible that the University of Helsinki does not have research activities towards ‘new materials’. In this case, it would be worth exploring possibilities for collaboration with other international groups. In any case, *an effort should be made in exploring the possibilities of plant genetic engineering.*

Dept. of Biotechnology and Chemical Technology

The department contributes to a number of areas under the University’s research priorities. Since the recommendations of SAB from 2014, a number of measures have been taken to strengthen the department, including new academic staff recruits and restructuring of the dept. into the Dept. of Chemical

and Metallurgical Engineering. The importance of the bioeconomy was highlighted, including the access to strong bioeconomy research infrastructure. The funding has declined since 2014 (across all funding bodies, except the EU). Publications are fairly good, but the number of higher impact (>7 IF) papers is <10% of the total papers.

The Dept. of Chemical and Metallurgical Engineering

The restructured department now includes metallurgy (which came out of the old materials science and metallurgy dept.) but it excludes biotechnology. This grouping appears to be somewhat artificial. Indeed, we are strongly concerned by the split of chemical engineering and biotechnology. At most universities there is a strong integration of these fields. It will be imperative to keep strong links with biotechnology (by working closely with the new Dept. of Bioproducts and Biosystems), as well as to forge concrete links to metallurgy. Metallurgy should not be an add-on but an integrated theme and mechanisms and inter-departmental and inter-school interactions should be put in place to ensure this. The capabilities and infrastructure of the new department are outlined, but it is not clear which major research themes are going to be pursued. We recommend that research themes, where Aalto can create an international reputation, are outlined. The open tenure track positions should then be filled in view of this strategy. We also recommend initiatives to maintain strong links across the education courses.

Chemistry Department

Since the last SAB meeting, the Dept. of Chemistry has taken on a major recommendation to provide research-focused areas as well as to employ 4 new tenure track people. All the new professors have been successful bringing in external funding. The number of publications has also increased with an average of 36% categorized as JUFO 3. There has been the creation of a MSC Programme in Chemistry and the use of Aalto-level digital learning platform. The department has benefited significantly from the RawMatTERS Finland Infrastructure, and has created international networks with 12 EU Universities and with USA and Japan.

Materials Science and Engineering Department

The dept. has been re-organized into 2 areas - functional materials and metals and minerals processing. A number of highlights in functional materials were reported and new bachelor and masters programs were rolled out. However, we note that the papers were predominantly at JUFO category level 1, with an overall decline in quality from 2014 to 2016. In the last 2 years, the department faced a significant challenge owing to the retirement of a significant number of professors, which had an impact on TEKES funding. Hence, the funding level overall declined from 2014 – 2016. We note that 2 significant programs, ELEMET and SIMP, are now almost finished and a funding gap will emerge from 2017 onwards.

Department of Chemistry and Materials Science

The Chemistry and Materials Science and Engineering departments have merged following retirements in Metallurgy and the need to rationalize space. The combined department has a healthy number of PhD students (43) and postdocs (15). The research is divided into 4 main areas: Functional Materials, Renewable Energy research, Chemical Synthesis and Numerical Modelling, the latter area cutting across the other 3 areas. There has been progress in organizing people under these themes. However, there is still considerable room for enhancing synergy and for creating a structure that would make the department

internationally competitive. In particular, Functional Materials and Renewable Energy would benefit from very strong interactions with the Dept. of Forest Products Technology and the Dept. of Biotechnology and Chemical technology, where overlaps in research areas exist. It is also unclear how the Circular Economy, which was mentioned as being important in the Materials Science and Engineering dept., will be implemented in the new combined department.

It is the panel's opinion that there should also be a very strong connection to Physics, which has major infrastructure in materials characterization as well as overlapping research themes. There is a need to take this combined expertise and forge research areas and teams to make the new department internationally competitive. Specifically, the Functional Materials and Renewable Energy themes should focus on 2-3 topics each where a critical mass of combined expertise exists. We note that numerical modelling is underpinning both functional materials and renewable energy. There should be more interaction of numerical modelling with activities in Physics and the Department of Biotechnology and Chemical Technology. We were concerned to see that chemical synthesis as a stand-alone unit. We believe that this synthetic prowess should be levered into design of functional and energy related materials. The great strength of working across the scales from atomic to system levels should be emphasised and implemented within the new research areas.

It is imperative to recruit the best students and professors. There is an opportunity to do this by interacting with Physics, with appropriate branding, international links, summer schools, etc., as reported elsewhere in the report.

8. Conclusions

CHEM is on the right track with its major reorganization, but it is time now to focus on research excellence. We have given recommendations on how to promote this by stronger internationalization, better branding, initiatives to renew the interaction with industry and by ideas to improve the operation of departments and the creation of more multidisciplinary projects in line with the vision of Aalto.

It may be beneficial to have a SAB visit when the reorganization has been implemented. For the next visit presentations should focus on follow up on recommendations, the SWOT analysis, and questions to SAB. SAB would need more information on developments in international rankings and details on publication performance. This should be planned in advance with the SAB chair and the material should be submitted to SAB well before the visit.