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Key Performance Index for Creating an Integrated and Sustainable Academy - A University with the Ability to Meet Future Needs and Challenges Identified in Society and Industry

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Abstract: Key performance indexes (KPIs) in various forms have always been used in one way or another in the production and processing of raw materials. The need for KPIs was accentuated with the advent of industrialism in the western world. The way and strategy of manufacturing industrial products has been divided into several so-called developmental transformations. Primarily after the depression of the 1930s and after the Second World War, a way of working and a basic view was gradually created that has resource efficiency and goal achievement as a fundamental idea. This publication describes how KPIs can be used in higher education to create a sustainable academy to meet challenges in industry and society over time. This with a focus on sustainability and continuity as well as a strategic integration between the academy's various missions. These missions consist of teaching, research and collaboration. Furthermore, according to the Higher Education Ordinance, teaching shall rest on a scientific basis and, when appointing senior positions, equal weight shall be attached to the merits that can be linked to teaching and research. In addition to teaching and research, collaboration must be conducted with the surrounding society. Society places increasing demands on the knowledge conveyed in teaching to harmonize with current needs and to prepare for future needs and challenges. A starting point for the publication is that needs and challenges can best be met through a conscious and strategic integration between the academy's various missions. Another aspect that is highlighted in this publication is the importance of strengthening the collaboration between basic subjects and more applied and industry-related subjects, which provides renewal in the applied subjects at the same time as the basic research can be utilized at a higher rate. In an industrial perspective, a more continuous TRL scale is obtained, which provides a more effective implementation of research results. A

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development path that strengthens the Academy's mission areas is the principle of affiliation of personnel from industry and other sectors of society and increased admission of industrial doctoral students and other external doctoral students. In order to monitor the development of the respective mission areas of academia and its integration, the use of KPIs will be addressed. A discussion of their benefits will be highlighted but also the associated difficulties, especially when conditions change. The conducted literature study shows that there are very few or rather no found publications dealing with KPIs for the integration of the Academy's different missions. KPIs are well developed for higher education in terms of its implementation and associated economics. Corresponding published work related to KPIs in research deals primarily with conventional academic bibliometrics.

Keywords. Key performance Index, KPI, academy, undergraduate education, research, industrial collaboration, challenges.

1. Introduction to Key Performance Index and their use in the academy

Industrially, KPIs have primarily been used to monitor the effects of decisions and their influence on the rate of change towards set goals. Japanese companies are considered to have played a major role in the use of KPIs in the establishment of an industrial transformation that later became known as Lean Production [1, 2]. During the further development of Lean Production, mainly during the 1990s, the use of different KPIs to describe production and its results was formalized at several different levels. The use of KPIs in an academic activity can serve three essential functions at the operational level:

1. Be able to follow the development of the activities over time, with a focus on the given mission and tasks according to the Higher Education Ordinance.
2. Provide decision-making support in order to achieve set goals in line with assignments and tasks and to steer operations in line with the stated strategy of the authority in question.
3. Follow the development and provide decision support for financial and organizational goals that also include work environment and leadership.

A prerequisite for being able to use KPIs in an appropriate and effective manner is that they can provide support for decisions linked to measures that are in line with a formulated strategy for the organisation. This strategy must be long-term and aim to provide guidance towards directly operational goals, which in turn can be linked to the Academy's main mission. By measuring and establishing relevant KPIs, decisions and measures taken can be evaluated in terms of effectiveness and rate of change over time. It is important that set goals are also sufficiently long-term and well anchored in the organization so that progress towards the goals can be measured and monitored over time. Rapid changes in business objectives and strategy mean that formulated KPIs become difficult to use and difficult to interpret, and partly lose their value as an effective decision-making aid. A change in leadership or a change in organisation must ensure that continuity can be maintained in the use of KPIs. In order to maintain the value of previous efforts in the area.

Different scientific subjects or activities in academia have different rates of change. The more industrially applied a scientific subject is, the higher its rate of change in order to adapt to new challenges and new needs. In education, this relationship is accentuated at master's level and during doctoral studies. If a comparison is made in an applied subject between an older and a newer course program at master's level, it can be seen that much of the course content has changed. If a similar comparison is made in a more basic subject at an earlier stage of education, the same conclusion is usually not reached. Different subjects therefore have different time constants associated with their development and therefore the use of KPIs will differ. For activities with a more managerial and time-stable character, KPIs should be developed that are primarily intended for performance monitoring. For an operation with a high rate of change, the KPIs also need to be able to serve as decision support to a greater extent. Different organizational levels within the Academy require complementary KPIs for overall decision-making at system level. It is therefore important that certain selected KPIs can also be aggregated vertically within the organization. This requires that the KPIs are clearly defined and interpreted in the same way in different activities.

The basic view stated below is based on an interpretation of the Higher Education Act [3], which clarifies that the mission of universities and colleges is described in three main areas: education, research and collaboration with the surrounding society. It also states that higher education shall be based on a scientific foundation. Against the background of the Higher Education Act, KPIs can be identified as shown in Figure 1. The KPIs are divided into seven groups, which directly reflect the mission and main tasks of universities and colleges. Groups 1-3 represent:

1. Education at undergraduate and postgraduate level.
2. Research and development.
3. Collaboration with the surrounding society.

An integration is required between these three main missions. This integration is very important and central in order for teaching staff to live up to the requirement that higher education should rest on a scientific basis and that our teachers should have direct contact with the research front and thus also have the opportunity to meet and provide answers to current and impending societal challenges, which is done through the results of their own and others' research. Groups 4-6 are formulated as follows:

4. Integration between research and education.
5. Integration between research, innovation and collaboration.
6. Integration between education, innovation and collaboration and knowledge transfer to society and industry.

In order to lead and run a successful education, research and collaboration with associated integration, a well-functioning administration is required, which requires good leadership in combination with a good working environment and good conditions in terms of resources. To describe these conditions, Group 7 is introduced and includes administration, finance, organization, work environment and leadership. Group 7 also includes qualitative KPIs that have been partly quantified to describe the staff's perceived working climate over time.

According to the above, KPIs can be produced linked to 7 groups or categories. The number of KPIs should be limited but must at the same time be so many that they can describe the activity in an appropriate way and thus contribute to a value-creating follow-up and provide support in various decisions that can contribute to the development. Below is a description and examples of each group and areas with examples of KPIs.

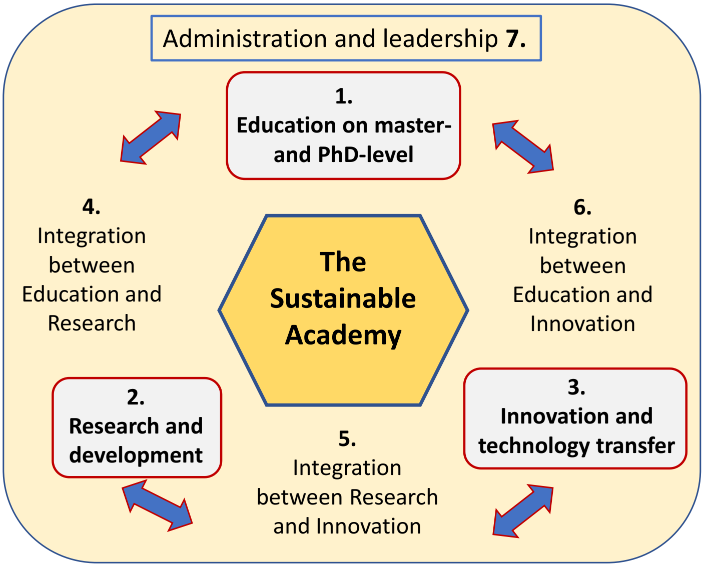

Figure 1. Identification of Key Performance Indexes linked to seven domains for use in the analysis, monitoring and management of the Academy and its development in order to achieve long-term sustainability.

Some KPIs can be placed in several groups as they are of an overlapping or integrating nature. The KPIs can also be expressed in several different ways, for example in absolute form or as a percentage in relation to a chosen reference. The reference can consist of the previous year's value or a decided target value. In many cases, it can be difficult to specify a KPIs target value. When it is appropriate to have a certain distribution, e.g., gender distribution, both a minimum and a maximum value can be used as target values, while several KPIs only have a minimum or maximum value as a target value. In some cases, the previous year's value may constitute a suitable basis for assessing a progression or development of the business.

Performed literature review: It can be noted that there are very few publications dealing with key performance indicators for the integration of the Academy's different missions. A case study has been conducted by Andersson and Sjöstedt [4] that focuses on the organization's finances, financial system and associated accounting. The case study notes that there is a need to update the key figures used over time to meet external accounting requirements. The work is based on the current code plan (chart of accounts), which also forms the basis for creating the information that can provide relevant decision support. Depending on what is deemed relevant, the authors, the current work can provide support for the various activities required to facilitate a value-creating integration between the universities' various missions.

A study by Lundqvist and Lundqvist [5] emphasizes that KPIs must be relevant to the business they describe in order to be used as a basis for decision-making. The requirements placed on the KPIs are treated in general terms, among other things, it is mentioned that the KPIs should be difficult to manipulate and easy to produce and easily linked to improvement opportunities in the business. The aforementioned requirements for key figures are also supported by other researchers referred to in the aforementioned work.

Work by Müller and Rijcke [6] is aimed at understanding how researchers themselves add value to research, and to what extent these practices are related to performance measurement. The article focuses on three key steps in the research process to show how metrics are becoming a central aspect of the research activity itself in terms of (1) planning and designing research projects, (2) the social organization of research processes, and (3) determining the endpoints of research processes. The researchers' findings [6] show how the value of research activities is increasingly assessed and defined in terms of their potential to deliver high value in quantitative terms. It can be noted that the reported work and its references more or less equate value with high bibliometric data, without seeing the direct value of integration with education or other exploitation of results.

Wu and Chen [7] propose and report on KPIs for higher basic education, covering many of the key elements of basic education from student enrolment, dropout and throughput rates, resources per student, proportion of time spent on teacher training, etc. At one point in the report, it is highlighted that it is an advantage if teachers are given the opportunity to participate in research.

Papers published in the addressed area deal with either research or higher education, as exemplified by [7, 8, 9]. Publications on education and metrics do not deal with e.g. the renewal of educational materials and content or its adaptation to emerging societal challenges. The works focus primarily on economics and the practical implementation of education and its results. The corresponding publications dealing with research have a primary focus on the choice of research questions that contribute to an increased number of publications, citations and increased H-index. No or very few works deal with the implementation of research results or how research results can renew teaching and higher education.

Limitations and starting point: The approach to the use of KPIs in academia in this report is shaped by the experience of sciences with an industrial connection [14]. These applied sciences are of an interdisciplinary nature that can span the entire TRL scale. Experience of the use of KPIs is to some extent taken from the manufacturing industry. The examples of KPIs presented are not definitive as the activities within an academy differ and where the chosen KPIs and associated target values must be adapted to each subject, its activities, goals and challenges. However, some interdisciplinary KPIs can be formulated, particularly linked to Group 7 as shown in **Figure 1**. Below is also the context and background that forms the basis for the examples of KPIs given.

2. KPIs for undergraduate and postgraduate education - Group 1

Group 1 ideally consists of two parts, one describing the undergraduate education (master's level) and one describing the postgraduate education. In applied subjects, it is common that later second-cycle courses are also given at doctoral level, especially when doctoral students are recruited externally and/or when students have a master's degree outside the core subject. In recent years, it has become increasingly common to recruit doctoral students with a more basic master's degree to industry-related subjects. This recruitment has provided great advantages in both doctoral education and research, while at the same time making it more difficult to reach a high level of understanding in the relevant degree subject. This situation limits the ability of doctoral students to participate, for example, as exercise leaders in the core subject's basic education. It is also common that well-developed third-cycle courses with associated course material are also given to undergraduate students at A-level, provided that the requirements regarding prior knowledge or alternative prior knowledge are met.

Three keywords have been used in basic education since the early 1990s: throughput, resource utilization and quality [4]. These keywords were established when the financing of higher education changed from being reimbursed for the number of places to being reimbursed for the number of credits awarded. This dramatic change increased the focus on recruiting the right students and implementing measures that strengthened the throughput of students.

A high throughput requires a high application pressure and that the right students can be recruited, this is especially important for master's programs, while at the same time the teaching can be adapted to the current students' conditions. This imposes deep insights and high competence requirements on the teachers concerned. In this context, it should be mentioned that the content and objectives of the programs, in terms of relevance to the labor market, must be completely superior to the application pressure. Otherwise, there will be low resource utilization and limited labor market value, which is contrary to the Academy's sustainability goals but also partly contrary to the ambitions of the Higher Education Act. Resource utilization is a composite parameter that is primarily affected by the number of students on a course, the students' dropout rate and the students' degree of graduation. The meaning of the keyword quality has changed over time, from only reflecting student satisfaction to also reflecting needs and societal benefits in the form of labor market value and employability. If good teaching conditions can be created in terms of course information, motivating content, implementation and examination, the three key indicators are usually well met. This applies to both undergraduate and postgraduate education.

With the above-mentioned budget change, the quality of education became increasingly important in order to meet the competition from other higher education institutions and not least from the newly established universities during 1990s. An important measure to strengthen the quality of education was to make better use of the available resources. An important way to go was to strengthen the collaboration between education and research, for example by using research equipment in teaching. This has also led to an increasing number of student encounters with researchers. In this context, doctoral education also strengthened its role in research. The increased volume of research conducted became more and more dependent on the participation of postgraduate students.

Successive increases in foreign trade and EU membership have increased the demands on industry to co-finance academic research, with reference to the state aid rules of competition law. This has been particularly true of applied and targeted research in academia. In order to strengthen collaboration with industry and its support in academic research, the concept of industrial doctoral students was formalized [11, 12, 13].

The quality of education or courses is made up of several components, including the competence of the teachers and their ability to innovate. Forms of supervision and teaching, course material and its adaptation to new conditions are also of great importance for students' motivation to study and thus also for their learning and ability to apply the knowledge gained.

Insights into the value of the content of individual courses and the combination of courses into entire educational programs have become relevant. The Academy's ability to constantly adapt courses and programs so that the content addresses current and upcoming challenges in society has become increasingly important for recruiting the right students. The ability to constantly adapt education to current and future needs emphasizes the necessity of an integrated collaboration between the university's various missions. Another prerequisite is that the course material used can be continuously influenced and changed. During the last decade, the practical application of acquired knowledge in the engineering profession has also increased in importance, resulting in a further strengthening of collaboration with industry. This is true for both undergraduate and postgraduate education.

A large number of KPIs can be formulated to describe the performance parameters that can be linked to the Academy's educational mission (Group 1). Exemplified KPIs in **Figure 2** and **Figure 3** are primarily linked to education at master's and doctoral level.

Master's degree - A specific study program

Application Pressure and Right Students

- First-time applicants per place.
- Number of admissions per place.

Quality

- Number of teaching hours per HST.
- Student satisfaction regarding content, resources and implementation.
- Gender distribution.

Program and course throughput

- Credit production.
- Student dropouts, number or percentage.

Resource utilization

- Graduation rate.
- Proportion of graduates with employment within 3 months of graduation.
- Proportion with employment in Sweden and in the EU.
- Cost in relation to revenue for the current master's program.

Figure 2. Example of KPIs linked to a master's degree.

3. KPIs for research and development - Group 2

Research and development is a central part of the Academy's activities. The aim of this mission is to develop knowledge and be a long-term knowledge carrier in society. Research and development is currently governed to a very large extent by the availability of external funding.

For applied topics, academia is also highly dependent on co-funding from industry and other actors due to the regulatory framework of the funding bodies. The co-financing requirements mean that new partners in the form of companies must be added annually to maintain continuity over time in the overall funding.

Over the past 10 years, strengthened collaboration between basic and applied research has proven to have a very strong potential for research results. This form of collaboration provides the conditions for integration across several TRL levels (Technology Readiness Level) [19], which creates the conditions for new solutions to more complex research questions. Research projects based on this approach have been difficult to finance as the financiers are locked to certain TRL levels. To be able to cover a sufficient part of the TRL scale, from basic research to industrial implementation, grants are required simultaneously from several different financiers, often also requiring complementary industrial donations or actively participating industrial doctoral students.

International research funding is also becoming increasingly important for academic activities. In these circumstances, the variability of research funding is often high, contributing to some uncertainty in funding from one year to the next. It can also be noted that the increased number of different funding bodies often leads to shorter project periods and at the same time more intensive funding, which makes it more difficult to plan the implementation of the research. With a short funding horizon, third-cycle education is often negatively affected as several different research projects are required during the third-cycle education. Another important factor to consider is that the time to recruit new staff is getting longer and longer due to the academy's administrative procedures, which do not harmonize with the nature of research funding.

In applied research, the volume of projects and their continuity is a clear indication that the activity delivers good results. As indirectly mentioned above, maintaining a large project volume over time requires a large network of industrial companies and established interdisciplinary collaborations within academia. A large project volume also provides good conditions for creating high bibliometric output.

Post-graduate education

Application pressure and the right doctoral students

- Number of eligible applicants per doctoral position.
- Proportion of applicants for doctoral positions with a degree in the core subject.
- Proportion of doctoral students graduating from their own academy.
- Proportion of industrial doctoral students
- Proportion of doctoral students who do not hold a doctoral position.

Quality

- Number of supervisors with unique responsibilities.
- Number of formalized courses.
- Doctoral student satisfaction regarding supervision, implementation and available resources.
- Gender distribution.

Throughput

- Credit production in relation to planned study time.
- Number of doctoral student dropouts.
- Number of ongoing industrial doctoral students who have passed the planned study period.

Resource utilization

- Number of doctoral graduates.
- Time to degree.
- Proportion with employment in academia after graduation.
- Cost in relation to income.

Figure 3. Examples of KPIs related to doctoral education.

KPIs to describe the results of research and development are often of a quantitative nature. **Figure 4** gives examples of KPIs for research and development (Group 2) that partly also overlap or may belong to another group.

<table>
<tr><th>Project volume</th><th>Bibliometric output and number of patents</th></tr>
<tr><td>o Project volume, turnover expressed in MSEK per year.
o Number of externally funded projects.
o Share of internationally funded projects.
o Share of funds via industrial donations.</td><td rowspan="5">o Number of publications linked to journals and conferences.
o Proportion of publications linked to Journals.
o Average number of authors per publication.
o Average number of citations for the 5 most cited researchers within the activity (Scholar and Scopus).
o The mean value of the H-index for the 5 most cited researchers within the activity (Scholar and Scopus).
o Average value of the i10 index for the 5 most cited researchers in the activity (Scholar and Scopus).
o Filed patent applications linked to the activity's research and development over the past 5 years.
o The number of popular science articles written in the last year.</td></tr>
<tr><th>Collaborations</th></tr>
<tr><td>o Number of active partners within their own university.
o Number of active partners at international academies.</td></tr>
<tr><th>Research efficiency</th></tr>
<tr><td>o Number of projects applied for in relation to projects granted.
o Average funding for granted projects.
o Average time span of granted projects.
o Average cost per publication.</td></tr>
</table>

Figure 4. Examples of KPIs related to research and development.

4. KPIs for interaction with the surrounding community - Group 3

Several KPIs within Group 1 and Group 2 have a strong link to external collaboration, Group 3. An example of this is how master's degree projects can form a direct part of both research and teaching, while at the same time degree projects are initiated by industry. Industrial doctoral students were established to create a natural contact area with the aim of directly exchanging knowledge and experience between academia and industry [11, 12, 13]. All applied research funding is based on collaboration between academia and industry. In these cases, the driving force often consists of finding research questions that industry is prepared to co-finance, while these research questions contribute to research that provides new knowledge that can be published and at the same time can be adapted to educational materials.

Industry also has a strong influence on research funders' prioritization of areas for research funding and related calls for research project funding. Together with industry, academia can have a major impact on society and influence decision-making authorities to speed up efforts to meet needs and impending societal challenges. This form of collaboration can lead to significant investments from authorities and other financiers in socially important research. An example of research funding created in this way is when the area of Production became a national strategic area (SFO) for Sweden. The educational mission described in Group 1 shall at all levels address issues that are relevant to meeting societal challenges, both in the short and long term.

The education and training mission is our main instrument for providing the labor market with skilled personnel. For this reason, we have to constantly develop and adapt our training to current and future needs. An upcoming important activity that will increase in importance is the training of industrial and other societal staff. This can be done in several ways, through regular industrial courses and increasingly combining industrial training with joint research projects, seminar series or individual seminars addressing current issues [15].

Another important form of collaboration with industry is the joint use of advanced research equipment and costly research infrastructure with high potential such as MAX IV. In this respect, adjunct and affiliated staff play a particularly important and central role in the integration between academia and industry [16]. **Figure 5** provides examples of KPIs describing academic collaboration with society and industry.

<table>
<tr><th>External collaboration related to education and training</th><th>External collaboration related to research and development</th></tr>
<tr><td>o Proportion of degree projects with an industrial link.
o Proportion of degree projects aimed at SMEs
o Proportion of industrial doctoral students.</td><td rowspan="3">o Number of adjunct professors
o Number of affiliated staff from industry.
o Proportion of research projects with industry participation.
o Proportion of research projects conducted in collaboration with SMEs.
o Number of active national industrial partners.
o Number of active international industrial partners.</td></tr>
<tr><th>Interaction related to other resources</th></tr>
<tr><td>o Number of direct industrial assignments
o Number of projects where industry uses the academy's unique equipment.</td></tr>
</table>

Figure 5. Examples of KPIs related to interaction with society and industry.

5. KPIs for research-education integration - Group 4

As mentioned earlier, the foundation of education is that it is based on science [3]. In this respect, academic research is very important for the development of education. The research shall also form the basis for successively training and developing the teaching staff, but also lead to the content of the education being at the forefront and contributing to the students being well prepared to meet the challenges of industry and the rest of society. The academies in Sweden and the EU have great ambitions by striving to be among the leading universities. By copying others, we can never become more than an average academy, so we must take full responsibility for our own future in terms of further development of teachers' knowledge and teaching methods, selected course combinations and course content, and the development and selection of course literature. It is of highest importance that we choose research projects that also support our education and contribute to its development in the above-mentioned respects. It is important that the applied subjects at the academies influence the funders' focus on new calls for proposals so that these are in line with impending educational needs that the societal challenges address.

A well thought-out strategy is required to adapt the results of research to the needs for renewal of courses and programs within a certain time frame. In some cases, research results can be directly used as examples in teaching; in other cases, more careful adaptation and knowledge packaging is required. There are good examples of how research equipment or experimental set-ups can be used fairly immediately in laboratories at master’s level and in postgraduate education.

Figure 6 provides examples of KPIs that can be used to monitor the integration between research and education. One KPI that is particularly interesting is the difference in the H-index between data from Scholar and Scopus. Scholar also considers course literature etc. while Scopus only considers research results in certain selected journals. This difference also partly gives an indication of the extent of written reports and publications that can be linked to collaboration with the surrounding society. This KPI may therefore be of interest to several of the groups described.

Research projects for the development of courses	Courses and course materials based on research
o Percentage of research projects initiated to contribute to course development. o Proportion of research projects with a specific work package aimed at adapting research results to education. o Proportion of degree projects that form part of a research project.	o Number of courses (credits) based on own research results. o Proportion of self-developed course literature used at master’s level and in doctoral education. o Educational elements at master’s level that use research equipment. o Average difference in H-index between Scholar and Scopus for the five most cited teachers.

Figure 6. Examples of KPIs related to the integration of research and education.

6. KPIs for integration between research, innovation and external collaboration - Group 5

The degree of application of a research area provides different conditions for direct interaction with industry. In recent years, the principle of conducting a stronger interaction across the TRL levels has been recognized. Through this form of collaboration between a basic subject, applied subjects up to industrial research and implementation, an unbroken TRL scale is obtained. This form of collaboration has a very high potential to produce new and unique research results. If a combination of interdisciplinarity and collaboration across the TRL levels is made, a further strengthened potential is obtained that provides the conditions for solving very complex issues such as creating the conditions for a sustainable circular economy.

In some cases, industry-academia collaboration requires that academia is also involved in the implementation phase of a project. This concept is particularly suitable for collaborations with SMEs that have limited academic experience. However, the approach places great demands on the staff involved from academia but often provides valuable new experiences. A new approach is being introduced for collaboration with SMEs [18]. The involvement of academia in the implementation of research results is an important development path that can give both academia and industry competitive advantages. Through this approach, academia and industry can jointly identify new research questions. This approach is formalized in three partially overlapping steps, where collaboration begins with training in the form of targeted seminars for industrial staff. The participants are given the task of identifying their own problem areas where the theory from the seminars is applied. After this second stage, development projects linked to the identified area are formulated and initiated, while supporting research is established in academia with relevance to the development project. The experience gained from the three steps is then added to the rest of the education at the Academy.

For larger companies with good academic experience, mobility programs for academic staff can be a good complement in combination with the affiliation of industrial staff to the academy [17]. This approach strengthens collaboration in several ways. Adjunct professors and affiliated staff are very important and central to achieving a strong integration between research and its application in industry.

Several of the exemplified KPIs in **Figure 7** can also be placed in other groups related to research and development (Group 2) and collaboration (Group 3).

New projects and the Academy's integration with industry	Use of academic research results in industry
○ Proportion of research projects in academia initiated by industry. ○ Proportion of jointly applied research projects with industry. ○ Number of patents granted together with industrial partners in the last 5 years. ○ Number of academic staff with positions in industry in the last 5 years.	○ Number of distinct implementations of research results in industry in the last 5 years. ○ Proportion of publications made with industry staff. ○ Number of Academy staff members who have participated in mobility programs in the last 5 years.

Figure 7. Examples of KPIs related to integration between research and collaboration.

7. KPIs for integration between education and outreach - Group 6

A central issue is to adapt our programs and courses to the needs of the surrounding society, both in the short and long term. With regard to this, it is very important that the research and teaching staff at a university of technology are well acquainted with the conditions and needs that exist and will exist in the future in industry. Research is primarily adapted to the future needs of education, while teaching is adapted to both current and future needs. It is essential that academia takes an active and conscious responsibility for this process. This issue is increasingly accentuated by the applicability of the subject or field and its proximity to industrial research issues. Degree projects represent an important interface in the integration of education with industry [14]. In many cases, adjunct and affiliate staff are key to an effective process of initiating and launching degree projects. A good way to create continuity around theses is to have a formalized process where existing and potential industrial partners are regularly approached and where proposals and descriptions of new theses are formulated in collaboration between industry and academia. A compiled and prepared catalog of possible thesis projects is particularly important for master's students due to available study time and residence permits, accommodation, etc.

In many cases, the research training of industrial doctoral students is strongly influenced by the research questions of the industry directly concerned and to a lesser extent is based on the ideas or visions of the academy. The absolute majority of graduated industrial doctoral students have carried out their doctoral projects in an area with strong relevance to their regular work tasks [13].

Other appreciated forms of cooperation are to invite industrial personnel as guest lecturers, make study visits with the students that are relevant to different course elements, create exercises that are directly derived from industrial issues, use photos and illustrations from industry in our teaching materials, etc. An appreciated element of the students is to discuss during study visits how different course sections have been applied and implemented at the company concerned. **Figure 8** gives examples of KPIs that can be used to illustrate how teaching is integrated with industry. The overlap of the KPIs for Group 6 is mainly in the description of the activities of industrial doctoral students.

Integration and adaptation of education to society and industry	Education's engagement with society and industry
○ Number of courses given for industry in the last 5 years. ○ Number of study visits per year for master's students. ○ Number of hours with guest lecturers from industry in master's courses. ○ Number of companies with which the Academy has a formal collaboration to develop proposals for master's degree projects.	○ Number of seminars directly addressed to industry. ○ Number of societal engagements of an informative nature dealing with education and its relation to research. ○ Number of positions of trust held by the Academy in various societal functions. ○ Number of research projects that have a separate work package aimed at industrial staff training.

Figure 8. Example of KPIs related to integration between education and training and interaction.

8. KPIs for administration, finance, organization, work environment and leadership - Group 7

Administration and finance is the most common area where KPIs have been used in academia so far. Most of the KPIs in Group 7 can often be added together from a lower organizational level to a higher level. Several KPIs are often already developed and are well defined in the activities' financial statements or in surveys that deal with employees' perception of the work environment, leadership and health, among other things [17]. The financial statements contain most of the financial data regarding, among other things, turnover, costs, internal overhead, external overhead above the activity, the distribution between different types of costs (distribution on the Academy's assignment), but also the personnel structure (number of professors, senior lecturers, etc.). In the event that these financial data are combined with other groups' data, for example, cost per publication or cost per teaching hour can be calculated, which can form an important basis for interesting KPIs that can be linked to both collaboration and indirect monitoring of the distribution of salary costs. Information from the financial statements often needs to be supplemented with, among other things, salary development for each personnel category, the number of employees and the extent of their involvement outside the institution.

The employee survey that is currently being conducted at several universities and colleges in Sweden is of great value for monitoring environmental and leadership issues. Comparisons can be made directly between different higher education institutions as the same questionnaire is used from Quicksearch AB [17], thus providing an important reference to the data of one's own academy. This survey includes relatively clear definitions and distinct questions that are suitable for use as a basis for valuable KPIs. These KPIs include the sub-areas of working climate, leadership, organization and vision and goals for the business. These sub-areas are in turn divided into several sub-groups, but without prioritization or weighting. The answers are given on a 6-point scale that is converted into a percentage from 0 % to 100 %. The subgroups are weighted together to give a percentage value within the range of 0-100 %. Based on the annual financial statements within the organization and in the employee, survey as suggested in [17], possible KPIs are exemplified in **Figure 9** for the current Group 7.

<table>
<tr><th>Financial performance during the year and retained earnings</th><th>Working environment, leadership, organization, vision and objectives</th></tr>
<tr><td rowspan="3">o Total turnover.
o Result for the activity as a whole.
o Share of turnover of basic education in the year.
o The performance of basic education.
o Share of external funding in total turnover.
o Balanced unspent funds.
o Retained earnings for education.
Retained earnings related to research.
o Total overhead cost.</td><td>o Working climate in %, 0 - 100.
o Leadership in %, 0 - 100.
o Organization overall in %, 0 - 100.
o Organization - Physical work environment in %, 0 - 100.
o Vision and goals in %, 0 - 100.</td></tr>
<tr><td>Staff and personnel structure</td></tr>
<tr><td>o Number of staff expressed in full-time equivalents.
o Number of professors and associate professors.
o Proportion of teachers with doctoral degrees.
o Percentage of teachers with an undergraduate degree in the core subject.
o Number of postgraduate students.</td></tr>
</table>

o Percentage of overhead cost for undergraduate education. o Percentage of overhead cost for research. o Rent cost for buildings and the cost per square meter.	o Proportion of technical and administrative staff. o Proportion of staff with a degree from their own academy. o Proportion of staff with less than 5 years to retirement.

Figure 9. Examples of KPIs describing finances, staff and service structure, work environment and leadership related to Group 7.

Figure 10 exemplifies calculated KPIs that are composed of data from several groups. These exemplified KPIs describe in some sense an economic efficiency.

Economic efficiency linked to the academy's mission
o Cost per publication, journal and conference contribution. o Average cost per teacher-led teaching hour. o Average time for a postgraduate student until examination. o Total laboratory cost per hour.

Figure 10: Example of KPIs that are composed of information from several groups of KPIs that in some sense describe an economic efficiency.

9. Conclusions and findings

In order to create effective academic activities and to live up to the intentions of the Higher Education Act, an integrated collaboration between the academy's various missions is required. The model presented above includes the Academy's three missions supplemented by three integration groups and a traditional group that broadly describes administration, leadership and work environment. The integration groups could very well be directly integrated into the groups for the three missions. The reported model intends to highlight and emphasize the importance of integration and collaboration between the Academy's missions, which is the reason why this groups have been formulated. This is done in order to highlight the great importance of integration and collaboration for the sustainable development of academic activities.

The basic view of the model is that undergraduate and postgraduate education should provide society (including academia) and industry with competent personnel who meet today's needs, but also have the knowledge and ability to meet imminent and partly future challenges. In order to realize this, current and future needs must be assessed and serve as a basis for initiating new and socially important research. Depending on the time scale for the future needs of society and industry, research will need to be conducted at different TRL levels, i.e., in the entire chain from basic research to applied research to industrial implementation. An alternative view often expressed is that the applied parts of the TRL scale should be carried out by institutes and consultants. This means that a compartmentalized approach is preserved in academia, which leads to an increased polarization between the teaching mission and the research mission. Educational issues are given low priority, while the academy's own students cannot compete for positions within their own organization. This basic view is completely at odds with the current law on higher education in Sweden.

The model presented therefore highlights the importance of collaboration within academia between basic and applied research. The task of research, regardless of its degree of application or time perspective until application, is to develop knowledge that can create value for society and industry. This means that teaching at different levels of education must be developed in an integrated way with the source of knowledge, i.e., research and development. The research and associated publications also contribute to awareness of the international research frontier, thus enabling the acquisition of knowledge from other academies and organizations that can enrich the education of the Academy itself. The combination and balance between our own research and knowledge acquired from other academies provides the conditions to meet our current and future needs in an effective way. This balance also gives our own education a unique character and content that leads to competitiveness. The integration shown in Figure 1 above contributes to an efficient use of resources combined with high value creation, which in turn provides the conditions for sustainable competitiveness that creates new resources. Academia and higher education have increased their interest in using KPIs in their development work in recent years. However, the Academy has a relatively long history of using financial KPIs for monitoring operations.

KPIs have also long been used in academia to monitor data in connection with the admission of students to educational programs in terms of admission scores, application pressure, gender distribution, age distribution, background, etc. Furthermore, KPIs have been used officially since the early 1990s to describe the students' experience of their education via course evaluations in various forms. KPIs linked to course evaluations are a good example of how these have been used early on as decision support for taking measures linked to specific courses or programs. In research, economic and bibliometric KPIs have dominated in academia.

The reported examples of KPIs, divided into 7 groups, aim to develop the content and working methods of an academic activity with a focus on collaboration and integration between the academy's different missions, but also emphasize the importance of collaboration between different disciplines and linking research at different TRL levels in order to find optimal development paths towards prosperity and sustainability in society.

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