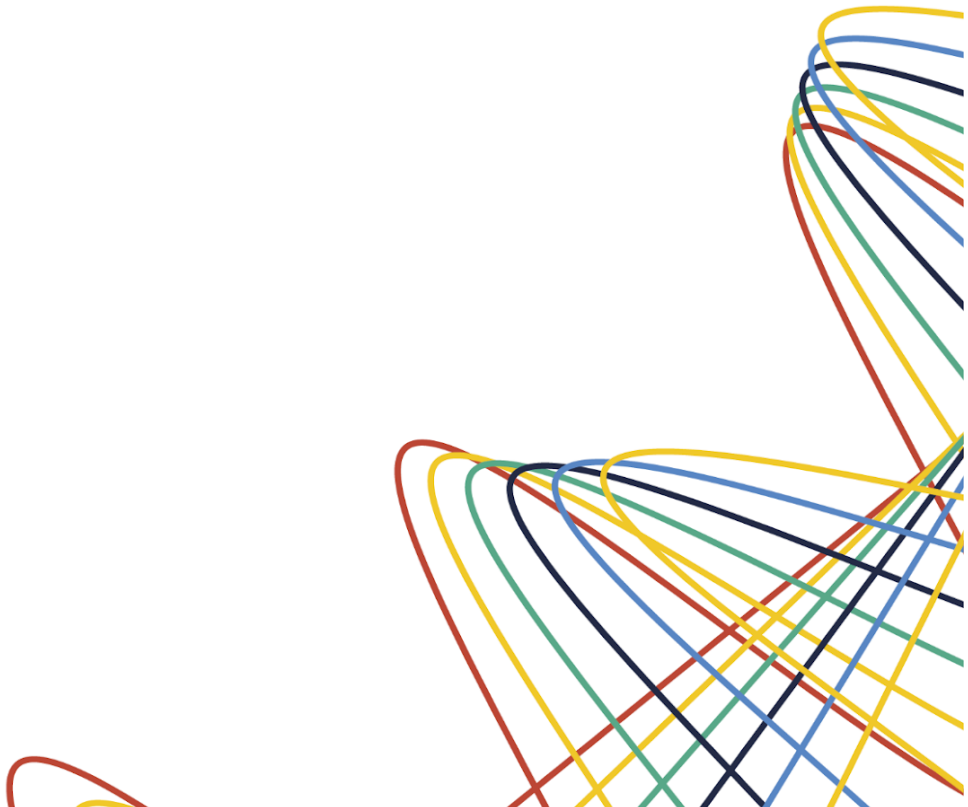
CONSTRUCTOR INSTITUTE

Quality management handbook



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Preamble

Constructor Institute is small, but its ambition is big: to become a major force in the world of top-level research and education institutions world-wide. Reaching this goal requires a focus on quality: not just performing after-the-fact quality control, but instilling into the daily practice of everyone at Constructor a constant concern for quality and a pervasive team effort to maintain and improve the quality of all processes, including both those that define the Institute's goals (education, research, technology transfer) and those that support these goals (management, administration, human resources student services, marketing).

We use a simple definition of quality: conformance of results to goals. (A software engineer would say: of implementation to specification.) Throughout Constructor Institute processes, and throughout this document, we remain on alert for cases of *non*-quality – deviations between the goals and the reality – and devise ways to avoid them in the first place, detect them when they happen anyway, correct them and their consequences, and reflect on the lessons learned so as to avoid further deviations in the future and improve the processes themselves.

In ensuring quality at Constructor Institute we are fortunate to benefit not only from the general literature on quality assurance, and from the European and Swiss standards on education, but also from our own experience in the original field of research at Constructor Institute: software engineering. The problem of quality is paramount in software development, and the field has developed concepts, standards and processes that can benefit the improvement of quality in other contexts, notably, as here, the organization of research, education and technology transfer.

The present Handbook describes the processes and standards that Constructor Institute applies to guarantee the quality of its offerings and activities for the benefit of students, researchers, colleagues, other members of the Constructor ecosystem, and society as a whole. They are meant to be regularly updated as Constructor develops and experience brings its lessons; indeed they contain mechanisms for their own improvement. We hope that they will guide everyone in the institution and help bring to Constructor Institute the success it deserves.

Manuel Oriol
President

August 2023

Bertrand Meyer
Provost

Table of Contents

1. Introduction

Current and future generations of students and researchers will have to solve the world's most pressing and complex economic, social and environmental challenges. The mission of Constructor Institute Schaffhausen is to provide them with an inclusive environment fostering the acquisition and advancement of knowledge.

As stated in our Development Plan" [2][1], Constructor Institute is poised to become as a world-leading Computer Science (CS), Software Engineering (SE) and Quantum Technology (QT) institution through excellence in education, research, technology transfer, innovation and mentoring. The mission of Constructor Institute is to lead the way in both fundamental research, in areas such as formal methods and quantum communications, and applied research, in areas such as embedded systems and software engineering for AI.

Within Constructor Institute, Research and Education fall under the direct leadership of the Provost (as VP of Research & Education), who together with the Education Office and the Program Directors (see the Organization and Governance document [4]) are the actors and units specifically in charge in defining, enforcing, monitoring and improving our quality standards.

Reaching Constructor Institute's ambitious goals requires a relentless focus on quality. The present Quality Guidelines describe Constructor Institute's quality policies. Section 2 presents quality principles. Section 3 introduces a number of quality disciplines inspired by the lessons of quality management and quality assurance in software development, a field where quality is of critical importance. Section 4 presents the process of quality management at Constructor Institute, derived from the principles and disciplines. Section 5 lists references.

[1] Numbers in brackets, such as [1], refer to documents cited in the References section (section 5).

2. Quality principles

The pursuit of quality at Constructor Institute is based on the following guidelines.

1. **Scope**. Concerns for quality permeate the activities of Constructor Institute, across all dimensions, the spirit of *Total Quality Management*:

- Across processes: Quality applies to all processes, whether related to management, marketing administration, education, or research.
- Across time: For every process, quality intervenes before, during and after execution of the process.
- Across people and roles: Quality is a concern for all stakeholders of Constructor Institute processes, including management, faculty, non-faculty researchers, administration, marketing and students.

2. **Publicity**. Core Constructor Institute processes are precisely documented and easily accessible to Constructor Institute members and any relevant others.

3. **Scaling**. Constructor Institute is, at the time of writing, a small institution in terms of educational programs, faculty size, number of researchers. Significant growth is planned; the quality criteria and processes are designed to ensure that they can accompany and support that growth.

4. **Simplicity**. Quality does not come from the accumulation of procedures and documents but from well-defined and focused practices, which every stakeholder can understand and apply.

5. **Self-Improvement**. Quality Management includes mechanisms for its own assessment and revision.

6. **Currency**. Quality management at Constructor Institute up to modern standards of quality control, including ideas learned from quality assurance in software engineering, which has developed particularly illuminating concepts and procedures for enforcing quality.

7. **Honesty**. The quality management process recognizes that deficiencies – in other words, instances of non-quality – will arise; to be corrected, they first have to be acknowledged honestly and openly.

8. **Compatibility**. Quality processes at Constructor are in line with international standards and practices in education and research, in particular those in force in Europe and specifically in Switzerland.

9. **Practicality**. Constructor Institute is devoted not only to academic pursuits, but to practical applications of its research and teaching. Quality enforcement techniques always include a view to the consequences on entrepreneurship, interaction with industry partners, and stakeholders' future careers.

10. **Ethics**. Enforcing processes and standards benefits all stakeholders of Constructor Institute and respects the specific needs, goals and concerns of all. Quality management respects the rules of ethical behavior and the overall goal of Constructor Institute as an institution: to benefit humankind.

3. Quality disciplines

In application of the preceding principles, Quality Management at Constructor Institute adheres to three important combinations of practices, which we call *disciplines*, a term borrowed from the CMMI (Capability Maturity Model Integration) model of the US Software Engineering Institute [1]. They are: **Before and After** (3.1); **Repair Cycle** (3.2); and **Level Assessment** (3.3).

Per principle 6, "Currency", all three disciplines bear a strong influence from quality practices in software engineering. The issue of quality is central in software, because modern programs are systems of enormous complexity, where every single detail can, if erroneous, cause the whole edifice to collapse. To give an example, the Windows 10 operating system has an estimated 50 million lines of source code. Substituting one character in one line, that is to say one in a billion elements, may cause Windows to produce wrong results and a catastrophe (possibly after a long period of seemingly normal operation by hundreds of millions of people)[2].

This extraordinary quality challenge has led the software field to develop unique quality management techniques. Some of them, in particular the three disciplines reviewed here, have important potential applications outside of software, in particular for the quality management system of a university. Since Constructor Institute's expertise and domain of activity is in part in software engineering, it is natural that our quality management should draw inspiration from these ideas.

3.1 Constructor Institute Discipline: Before and After

The first discipline addresses one of the basic questions of quality: integrate quality concerns into processes (*a priori*) or check results for possible deficiencies and correct those found (*a posteriori*)? The lesson of software engineering is clear: neither approach is sufficient, and both are necessary. Specifically:

- If quality is not built into processes and into the institution's culture, no amount of a-posteriori checking will suffice to remove problems.
- Even with the highest focus on a-priori quality, defects will remain. The results must be subjected to systematic assessment (known in software as *verification*). The saying "Trust but Verify" humorously captures this (very serious) idea.

These observations explain why the present document does not limit itself to terms such as "Quality Assurance" and "Quality Control" but is devoted to *Quality Management*, which includes both aspects.

Hence the first discipline: **Before and After**. Quality Management for any Constructor Institute process, procedure, service or product should integrate quality concerns throughout its lifecycle and include mechanisms for verifying the actual quality of the results.

Summary definition of the Before and After discipline

Before and After

[2] Assuming that lines have 20 characters per line on average and that the changed code still compiles. We could transpose the observation to the binary code where a similar situation could ensue from changing one bit in about 1 GB, i.e. one element in 8 billion.

Combine a constant concern on quality, throughout Constructor Institute processes, with rigorous assessments of the results

Example application of the Before and After discipline in Constructor Institute processes

Scenario: Documents produced by various branches of Constructor Institute follow different standards.

Solution: as part of the current effort to produce a consistent set of documents as part of the preparation for accreditation:

- We defined a standard format for Constructor Institute documents, with standard front matter (report number, date etc.).
- We defined basic conventions (such as the use of US English spelling).
- We provided templates, available on the Constructor Institute Intranet.
- We applied the "six-eyes" principle: every document should be reviewed by at least three people beyond the author(s), including at least one academic and one non-academic.
- We made it known that every writing effort should apply these standards from the start.

Lesson drawn: advice is good, directly usable artifacts are even better.

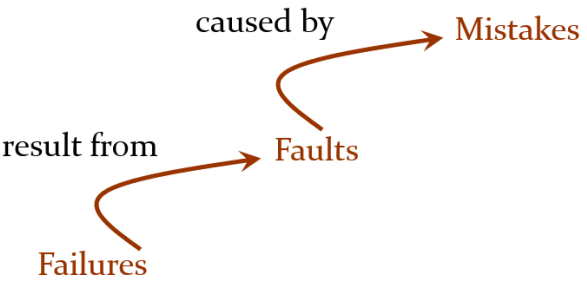
3.2 Constructor Institute Discipline: Repair Cycle

Defects, as noted, will creep in. Quality Management should include – as part of its "a-posteriori" component – a procedure for handling defects.

Terminology: we use "defect" as a generic term to cover mishaps, but when more precision is needed one can refer to three levels used in engineering and standardized by the IEEE (Figure 2):

- A particular process encounters a **failure**, an instance of malfunctioning. For (non-software) example: a student who should have passed a course is recorded as having failed it.
- The failure is caused by a **fault**: something was not done right (here in the design of the grading process or its execution).
- The fault is itself due to a **mistake**[3]: a human did not do the right thing (in preparing or executing that process.

The fault[4] is in the process or product; the mistake is in a human's thought process.



[3] In that standard terminology, "error … specific meaning of a numerical deviation, as in "surveys of … an error of at most 2".

[4] Commonly called a "bug" in softwar…

Figure 1: The causal chain for defects (source: IEEE)

The a-priori component of Quality Management concentrates on preventing mistakes (to prevent faults that would cause failure). On the a-posteriori side, it is important to have a well-defined process. Here again we at Constructor Institute learn from the lessons of modern software engineering. Work on "Automatic Program Repair" (APR, the task of automatically generating a correction for a faulty program) has led, particularly in an influential recent survey paper [6], to distinguishing four steps of the Repair Cycle discipline illustrated in Figure 2[5].

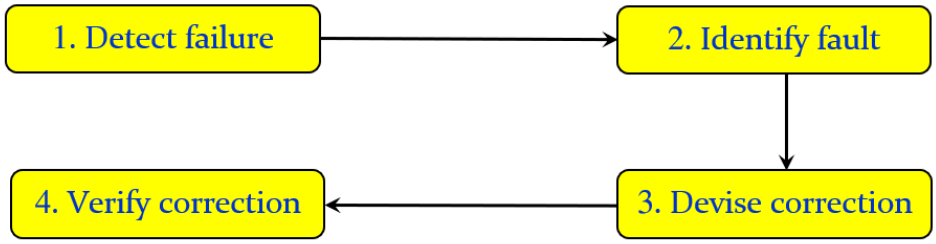


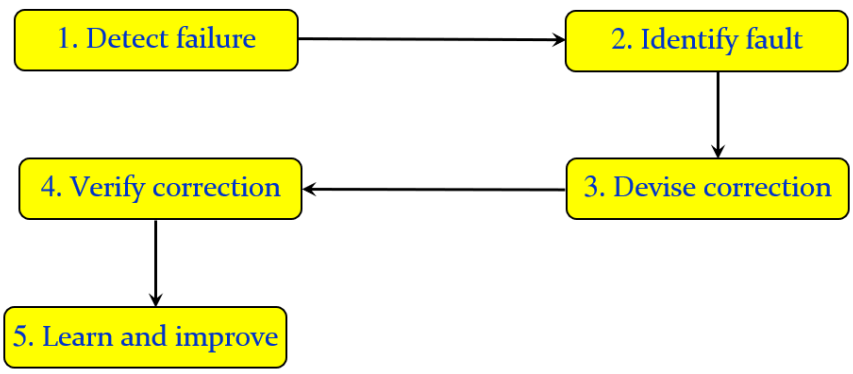
Figure 2: Repair Cycle (basic)

Once a failure has been detected and confirmed, the corresponding fault should be identified. Then a correction has to be applied. This step is not the last one, as the correction itself might be wrong, or cause worse problems! The last step consists of verifying it.

In a comprehensive Quality Management scheme including an a-priori view as well as Self-Improvement (Principle 5) there is yet another step. We cannot just stop with the satisfaction of having fixed one problem. We must make sure that:

- No similar faults remain elsewhere.
- No new instances of this fault or similar ones will occur in the current process and future ones.

In other words, we must go beyond the fault (the symptom) and identify the mistake (the cause) – the human mishap that led to it and could do so again in the future. The full Repair Cycle discipline at Constructor involves the scheme of Figure 3.



[5] Reference [6]

Figure 3: Repair Cycle (full)

The added element (step 5) complements the reactive nature of the preceding ones with a proactive component, leading the team to analyze the root causes and improve future processes thanks to the lessons learned.

Example application of the Repair Cycle discipline in Constructor Institute processes

Scenario (hypothetical): A student complains about her grade in a course (step 1 in Figure 3). The grade includes a project component and projects (resulting in a program) was performed in groups of 3 to 5 students. She says that she did all her parts right but the other team members stopped responding and did not fulfill their own commitments.

Solution:

- (Step 2 in Figure 3.) (A) examine the records of the configuration management system, which show precisely what code elements each student delivered. (B) Talk to all the students in the project group, to obtain all viewpoints, and to the Teaching Assistant (TA).
- (Step 3.) Noting that indeed the other students were considerably less productive, modulate the project grades per student instead of a single grade for all project members. Adapt course grades accordingly.
- (Step 4.) Check that the modulated grading is in line with the rules for the course and for grading at Constructor Institute in general. If in doubt, get the Provost's approval. Notify the student.
- (Step 5.) Update the syllabus to require (in future editions of the course) that students, as part of their deliveries for the project, include a short paragraph describing the extent of individual contributions and, if applicable, another one describing any disagreements or tensions within the group, so that problems can be identified early in the project and not after grading. Make sure that the project description includes a discussion of potential issues and an encouragement to report communication or personal issues to the TA as early as possible. Update instructions to future TAs to make them aware of these issues.

Lesson drawn: Student projects are human endeavors with social and psychological components, which can lead to conflicts. This aspect should be recognized, and handled proactively both through documented processes in the projects' description and through awareness of all the teaching personnel involved, TAs as well as other instructors.

Summary definition of the Repair Cycle discipline

Repair Cycle

Apply the 5-step process of defect identification and repair.

3.3 Constructor Institute Discipline: Level Assessment

In software project management, a major influence has been the CMMI framework [1] developed by the Software Engineering Institute, a unit of Carnegie-Mellon University funded by the US Department of Defense (DoD). Evolving from a software-only model (called CMM for Capability Mature Model), CMMI is actually applicable to many different disciplines, as suggested with the added "I" for "Integration".

CMMI involves many concepts; one that is particularly relevant for the operation of Constructor Institute is the definition of "Maturity Levels" (Figure 4).

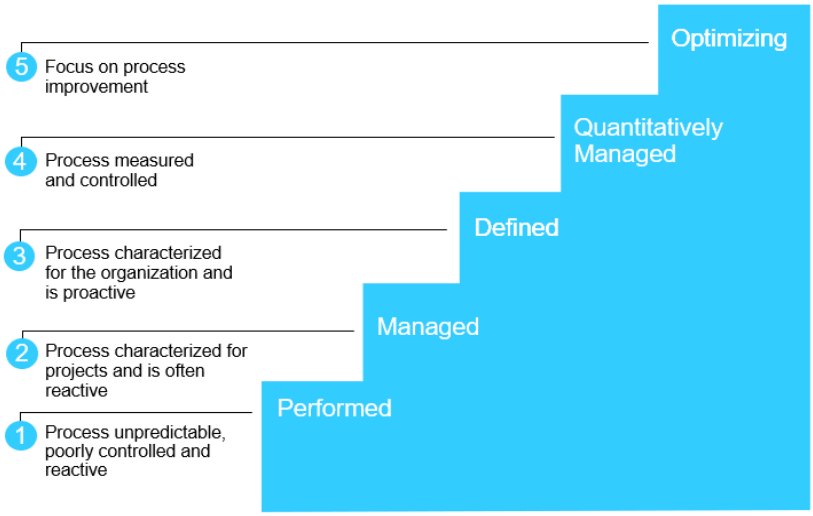


Figure 4: CMMI maturity levels

The levels describe the degree of control that an organization exerts over its processes. These processes can be of any kind: software processes (in the original CMM), but in the application to an organization such as Constructor Institute any organizational processes. To reach a level it is necessary to have gone through all the preceding ones. Their characteristics are the following:

- At the Performed level (1), the organization carries out its processes and projects, but has little or no formal description, let alone measurement, of them. Things "just happen". As a result, some projects may be successful (possibly many of them), some fail, but no general lesson emerges and every new project is an adventure. The following levels will introduce increasing levels of *reproducibility* and predictability, making it possible, on the basis of experience recorded for previous processes and projects, to foresee and even guarantee, within decreasing margins of error, the characteristics of a new project.
- At the Managed level (2), individual projects have defined and documented their own processes. There is no corresponding policy, however, encompassing the scope of the whole institution. In addition, processes are still largely reactive, responding to specific needs rather than following from a general policy.

- At the Defined level (3), the institution has overcome these limitations: there is an institution-wide process description, providing a proactive attitude; it is precisely documented and applied. (Such documentation and control were already present for individual projects in level 2, but here the focus is on extending these policies to the organizational level.)
- At the Quantitatively Managed level (4), a systematic measurement and tracking policy is in place, using techniques of statistical project management. (Quantitative assessment disciplines are already present in levels 3 and 2, but here it is the focus at the enterprise level.)
- At the Optimizing level (5), all the basic mechanisms of the preceding levels are already in place, and the focus has shifted from making them work to improving them. (Process improvement disciplines too are present at all preceding levels, but here they become the focus.)

CMMI is widely used by software companies – initially providers of the US DoD, then Indian outsourcing companies when they wanted to establish their credentials, and nowadays a very wide range of organizations – to establish and advertise their mastery of their own processes. In such industries, organizations do not just assert their maturity level: they must qualify for it through an arduous *certification* process. Certification is performed by specialized agencies; it typically takes significant time (such as the estimated 18 months to go from level 1 to level 2) and significant investment, accompanied by in-depth changes to the institution's processes. Constructor Institute does not intend to start such an official assessment, which is not justified in the present state of the institution, but does intend (as other institutions have done when they felt that CMMI concepts were useful but did not require a certification as a condition for doing business) to perform regular self-assessment, with the following milestones:

- Level 2 (managed): March 2023 to September 2024, as part of the present effort towards accreditation.
- Level 3 (Defined): October 2024 to December 2025.

Progress towards these goals shall be regularly assessed by the Continuous Improvement Committee (section 4.9).

Example application of the Level Assessment discipline in Constructor Institute processes

Scenario: In the day-to-day operation of Constructor Institute, short-term needs and deadlines may cause quality practices to slip.

Solution: We have established a Continuous Improvement Committee (section 4.9) consisting of representatives of major Constructor Institute stakeholder categories, charged with monitoring quality throughout and required to report regularly to the management.

Lesson drawn: Continuous improvement must be built into the very fabric of the institution.

Summary definition of the Level Assessment discipline

Level Assessment
Strive to obtain CMMI-style maturity levels by defined dates, and monitor progress towards this goal.

4. Quality Management system, processes, and goals

The primary quality goal for Constructor Institute is to achieve CMMI level 4 organization status by 2017. This includes having systematic measurement and tracking policies in place, utilizing statistical project management techniques.

Constructor Institute is dedicated to achieving excellence in learning, teaching and assessment by providing high-quality educational programs. The Quality Management system, processes and related factors of success will offer guidance and monitoring tools to attain these goals. As stated in the preamble, we use a simple definition of quality as the conformance of results to goals.

In accordance with the previously outlined quality principles and disciplines, Constructor Institute's Quality Management system and processes aligns with the European Framework for Quality Assurance. This section follows the same structure as Part 1 of that Framework (down to 2nd-level numbering, e.g. 4.1, 4.2 etc., with 3rd-level sections such as 4.1.1 added for readability).

4.1 Policy for quality assurance

Various actors, each with distinct functions and responsibilities, actively participate in the Quality Management system to ensure the quality of Constructor Institute's offerings, activities and results, with students playing a central role.

4.1.1 Terminology

The following roles and functions are defined in the Governance document [4]:

- **President**: operational leader of Constructor Institute.
- **Provost**: leader for academic matters – education, research technology transfer.
- **Program Director**: professor in charge of a particular educational program.

The following terms are defined in the Faculty Statute [3]:

- **Professor**, encompassing three levels: assistant, associate, full.
- **Adjunct professor**: member of another institution who conducts some academic activities at Constructor Institute, and would be entitled to professor status, but is employed at Constructor Institute on a part-time basis.
- **Faculty**: the set of professors (including adjuncts). This term is not used to devote any formal body (see instead the next one), simply as a collective singular synonym for "the professors".
- **Academic Senate**: the committee made of professors (restricted to those with 50% employment or more), supporting the Provost in academic matters.

Additional terms are:

- **Instructor**: someone who participates in the teaching a course. Typically, instructors are Constructor Institute professors or adjunct professors, but others may be involved, such as an external instructor (from another educational institution or from industry) or a postdoctoral employee (postdocs).
- **Teaching Assistant**, abbreviated as TA: a member of Constructor Institute who supports the teaching of the course (rather than actually being responsible for lecturing, as an

instructor is). Typically, TAs are responsible for exercise sessions (also called "labs"), for helping students with assignments and programming, and for helping with grading assignments and exams. TAs are generally PhD students and postdocs from the research chairs at Constructor Institute; students from previous classes can also fill some TA roles.

- **Supervising professor(s)**: for a course: the professor (occasionally, more than one) officially responsible for the course (see 4.1.3 below).
- **Teaching team** for a course: the Supervising Professor(s), any other instructors, and TAs.
- **Ombudsman**: a member of Constructor Institute tasked with examining and seeking to remedy potential deficiencies and malfunctions.

4.1.2 Organizations

While quality is the responsibility of all stakeholders at Constructor Institute, the following units and personnel of Constructor Institute are specifically in charge of defining and enforcing quality standards, processes[6]:

- The Provost.
- The Education Office, under the direction of the Provost.
- The Program Director for a particular educational program, part of the education office.
- The Ombudsman.
- Support services, particularly IT (Information Technology) and HR (Human Resources).
- The Continuous Improvement Committee (section 4.9).

Constructor Institute's emphasis on high-quality educational programs places significant importance on the role of Program Director. The Program Directors provide academic leadership over curriculum enhancement; they oversee the student experience all the way from recruitment to graduation and beyond. One of their key responsibilities is Quality Management and Enhancement. They actively engage in Round-Table conversations with students (see next), They serve as points of contact for students on critical issues related to program design, delivery and outcome assessment. Additionally, they regularly evaluate feedback from students, instructors and the Continuous Improvement Committee and initiate appropriate action when required. They provide support and relevant input for periodic review of programs and implement changes agreed upon during the review process.

Success factors: one of the key success factors is the organization of an annual Round Table for each educational program with students (open to all students), under the supervision of the Continuous Improvement Committee, leading to the definition of precise action points for implementation and monitoring. Follow-up sessions, also related to quality management processes and their results are conducted in the subsequent academic year to track progress.

4.1.3 Supervising professor(s) for courses

Any course at Constructor Institute shall be taught under the responsibility of a "supervising" professor, occasionally more than one jointly.

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[6] For a detailed overview of the structures at Constructor Institute Schaffhausen, see the Governance document [4], in particular the summary in its Figure 4.

The teaching of the course may involve other instructors, but in all cases the supervising professor(s) shall teach a substantial part of the course and are responsible for its successful execution and for addressing any problems that may arise in relation with it.

The Provost shall be responsible for professor assignments; any disagreements shall be brought up for discussion in the Academic Senate, with the Provost remaining responsible for final decisions.

If a professor expresses the desire to take over the supervision of a course currently taught by another professor who wants to retain it, and the teaching assessments are satisfactory (section 4.5.3), the current supervising professor shall, subject to the agreement of the provost, be given the opportunity to retain the course until having taught it at least three times (to compensate for the investment made into the preparation and ironing out of the course).

4.2 Design and approval of programs

The initiative for a new educational program may come from any Constructor Institute member or other stakeholder (such as a member of the Board of Directors). The process for introducing the program, as well as developing existing programs, according to the Quality Management cycle, is conducted under the leadership of a professor ("promoter"). The Quality Management cycle involves the following steps:

1. The promoter, with the support of the Education Office, prepares a description of the program with all elements necessary for evaluation, including the purpose, benefits to Constructor Institute, alignment to its strategic orientation and its students, list of courses, syllabi (including learning outcomes, see 4.3.1 below), comparison with existing programs in other universities (or, if none, justification of the program's novelty) and possible instructors.
2. The description is presented to the Academic Senate for discussion and assessment, and examined promptly. The proposal goes ahead if approved by Academic Senate (majority vote).
3. The Provost evaluates the practical implementation of the program, including its accreditation or effect on existing accreditation. Any significant changes to the program require a repetition or update of steps 1 and 2.
4. Final approval, including any budget decisions, is the joint responsibility of the Provost and President of Constructor Institute.
5. If in steps 2 to 4 the proposal encounters serious objections not permitting approval, the Academic Senate shall decide between: (A) encouraging the proposers to make adjustments for resubmission at a subsequent session; and (B) rejecting the proposal, with a clause that any proposal in the same area shall be treated as new and considered only after a cooling-off period of at least one year.

The criteria for assessment of a proposal (steps 2 to 4) are:

- Educational value, learning outcomes.
- Compatibility with the four purposes of education as defined by the Council of Europe (see [10]).
- Alignment with the goals and strategic directions of Constructor Institute.
- Potential relevance to students' careers.
- Compatibility and complementarity with existing programs at Constructor Institute.

- Evidence that the proposal has been carefully thought out and in particular has been discussed with relevant stakeholders, particularly students, as well as industry partners if applicable.
- Evidence that the proposed program reflects the state of the art in its area.
- Readiness of the program: are instructors available? Are the syllabi complete and credible?
- Comparison with programs at other universities (taking into account both that the existence of similar programs elsewhere reinforces credibility, but also that Constructor Institute is an innovative institution ready to embrace new topics not yet taught elsewhere).

Every approved program shall have a Program Director, appointed by the Provost for a period of 3 years, renewable. The Program Director shall be a professor of Constructor Institute.

The same procedure applies to any significant revisions of an existing program. Minor revisions, such as syllabus updates and change of faculty, are the responsibility of the Program Director with approval from the Provost, who may ask for the approval of the Academic Senate if appropriate.

Key success factor: the implementation of the Quality Management cycle at every step during the introduction of each new program or the development of an existing one.

4.3 Student-centered learning, teaching and assessment

4.3.1 Course syllabus

In advance of the execution of a course and of the period for course selection by students, a course description (syllabus) shall be made available to students and faculty, including:

- Title and short summary.
- Learning outcomes.
- Teaching team (supervising professor(s), any other instructors, TAs if any).
- If the instructor in charge is not a Constructor Institute professor (e.g. the instructor in charge is a postdoc, or an external instructor), supervising professor from Constructor Institute.
- Prerequisites if any.
- List of topics and lecture plan.
- Assessment method.
- Grading units, such as: regular homework or other assignments; midterm exams; final exam; project.
- Any required or recommended textbooks.
- Practical information (course's web page, repository of recorded lectures and other materials, instructions for submitting assignments...).
- Any specific rules, such as the permission, or not, to use artificial intelligence and other tools.

The Education Office maintains a simple form to be filled by the instructor (with approval from the supervising professor if any) before the start of the semester, and updated as needed each

time the course is offered again. The content in the syllabus has to align with the information on courses provided in the Program Handbook.

In addition to these steps, the course leader is attentive, throughout the execution of a course, to the success of the learning process and to any problems that may arise, to enable an early proactive (prevention rather than cure) action whenever possible.

Key success factor: preparing a syllabus for each course according to the template provided by the Education Office and making it made available to all students before the start of the semester.

4.3.2 Course page

Every course shall have a Web page in the web site of Constructor Institute, managed directly by the teaching team (which may edit it directly without going through a specialized Web editing team). The Web page shall include the course syllabus and other relevant information, and shall be updated regularly as needed with relevant news and announcement.

Constructor Institute shall also offer student forums, possibly moderated, to allow discussion of courses.

4.3.3 Teaching techniques

Teaching at Constructor Institute uses a mix of advanced pedagogical techniques to provide students with the most effective learning experience. This commitment goes beyond simple dedication to the educational part of a professor's activity: several members of the Constructor Institute faculty actually have Computer Science Education as one of their active research areas, with collectively over 30 education-research publications in the past two decades (see e.g. [14]) at top international venues such as SIGCSE and ITiCSE, and have given keynotes at major computer science education conferences.

Distinctive features of teaching at Constructor Institute include:

- A combination of onsite and remote education. All our courses are designed for this hybrid model.
- Extensive student involvement, through numerous student projects.
- Extensive use of "flip learning", with lectures driven by students asking questions rather than the instructor covering material.
- Close feedback loop, with frequent assignments graded quickly, and frequent discussions with students about the progress of the course and elements to be improved.
- Use of technology support, as discussed next.
- Emphasis on small groups of students to foster interaction.
- Emphasis on multi-student projects, to promote communication and collaboration skills.

The following are examples of teaching techniques in two courses of the Computer Science , Software Engineering and Leadership master program (since 2021):

- The "*Software Construction, Architecture and Engineering*" course is a review of fundamental techniques in software, devised to bring all students to the same mastery of essential material. It uses a "**trio**" system as follows. Each lecture is accompanied by a pre-recorded instructional video, part of Constructor Institute MOOC (Massive Open Online Course). The first part of the trio is the requirement that students take the

corresponding MOOC lecture by a set day. The second part is an interactive lecture in which, by default, the professor does not volunteer materials but answers students' questions about the MOOC lecture, in a "Socratic" flip-learning style. The final part is an exercise session in which the students solve exercises under the guidance of the TAs . This system has proved extremely successful; after a week or two of hesitation (as most students are not used to teaching methods requiring so much active participation), they start coming up with questions and the interactive sessions (part 2) become rich with useful lessons for everyone.

- The "*Capstone*" course is a unique feature of our program. In most universities it is difficult or impossible to engage students into realistic projects, because student projects typically happen in one course limited by the duration of the semester. These constraints make it very hard to teach fundamental skills of building large systems (limiting the students' experience to small programs, which are of limited relevance to industry). In contrast, the Constructor Institute Capstone is a project course running over three consecutive semesters (the full master duration save for the last thesis-only semester). In the course, students develop a significant system based on a realistic requirement devised in common with a Constructor Institute stakeholder or industry partner. The project is collaborative: the *entire class* makes up the project team, working together towards a common goal, through an experience which complements the inevitable individual components of ordinary teaching. The professor acts as a guide, coach, mentor and senior adviser to the project. Graduates have repeatedly expressed how useful the experience is to their professional advancement.

Key success factor: monitoring the satisfaction of student-centered learning and teaching through annual course evaluation surveys in accordance with the continuous improvement cycle.

4.3.4 Educational research

Continuing the long experience of education research cited in section 4.3.2, some of the Constructor Institute research chairs closely work with education technology partners from the Constructor Group to explore and integrate Artificial Intelligence techniques into teaching, with a PhD in progress on the topic.

Such research and its application to actual teaching at Constructor Institute carefully follow the ethical rules presented in the Code of Academic Ethics. In particular:

- While it is convenient and beneficial to perform assessments of teaching techniques on Constructor Institute courses, such cases observe rules of student privacy.
- The primary goal always remains education; research on education, if present, is a secondary goal.

Any use of Artificial Intelligence is subject to particular scrutiny (per the general guidelines cited in the Code of Academic Ethics).

4.3.5 Academic calendar

Constructor Institute follows the Swiss Academic Calendar for Universities defined by the CRUS (Council of Rectors of Swiss Universities). Its basic features at the time of writing are the following[7]:

- The "academic year" consists of two subsequent semesters, Fall and Spring.
- Semester dates are respectively mid-September to mid-December and mid-February to late May. (Exact dates depend on the year's calendar; for example, a semester normally starts on a Monday, and the Fall semester should end at least 3 days before Christmas.)
- Exam sessions may be scheduled in January and August.
- A "summer session" is possible for special courses and projects.

Graduation ceremonies at Constructor Institute take place in the second half of June.

As a consequence of these features the academic year extends from September of a calendar year to June of the next year. It is expressed in the style n—n+1, as in "the academic year 2023-2024". The academic calendar shall be communicated to students before the first semester start each academic year.

4.3.6 Language of instruction and operation

The language of instruction at Constructor Institute is English. It is also the default language for Constructor Institute internal and external publications (except for those that must for legal reasons be delivered in German or another of the official Swiss languages) and more generally for Constructor Institute's operations. English is also the language used in all student surveys. A number of reasons may justify exceptions to the use of English, such as:

- Foreign Language courses.
- Communication with third parties not fluent in English, or (for example in the case of government representatives or members of the local community) required or preferring to interact in a Swiss official language.
- Student forums. (For more formal written communication such as email between Constructor Institute faculty and staff, however, it is preferable to use English.)
- Mere convenience in day-to-day interactions, particularly verbal, between Constructor Institute members with mother tongues other than English.

The variant of English used for Constructor Institute documents is American English. For consistency and wide appeal, British word spellings and other specifics of British English shall be avoided.

4.4 Student admission, progression, recognition and certification

It is essential to provide students with fair and constructive assessment of their progress. (Note that the present section 4.4, particularly starting with 4.4.2, is about the assessment of *students* by instructors. Assessments of courses, in particular of *instructors* by students and management, is covered in 4.5 and in the Faculty Statute 26[3].)

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[7] See https://www.swissuniversities.ch/en/service/studying/studying-in-switzerland/academic-calendar-1_for_the_period_2023-2026. The relevant section is "for universities" (as distinct from Universities of Applied Sciences etc.).

Key success factor: defining assessment methods in the syllabus of each course before the start of each semester.

4.4.1 Student admission

Participation in Constructor Institute programs starts by default with the academic year. Special circumstances, the Provost and education office may authorize admission from the Spring semester, or more generally after the start of a semester. In addition, special programs, such as a summer program, may take place outside of the confines of the academic year. Calendar specifications in the following descriptions refer to the default scheme.

Student recruitment for programs in an academic year shall start no later than February 1st of the previous academic year. (Special circumstances, such as a new program, may justify exceptions, subject to approval by the Provost.) Programs shall be advertised using a variety of channels, including appropriate social media likely to be frequented by prospective students.

Every effort shall be made to ensure that good candidates are able to apply at minimum hassle. The minimum information to be provided is:

- Standard academic CV.
- Motivation letter.

Other elements (such as grade transcripts and references) are welcome and, if absent in the original application, can be demanded from applicants. Detailed admission requirements are described in the Program Handbook of each study program.

Applicants shall be evaluated on criteria including the following:

- Quality of prior education, including quality of the educational institutions (per standard rankings of universities).
- Grades in prior education.
- Prior experience. (In line with Constructor Institute' s practical orientation, we value not only the applicants' academic background but also any professional experience, including voluntary activities, with an educational value.)
- Student motivation and capacity for innovation.
- Potential effect of admission on Constructor Institute's equality and diversity guidelines (in line with the principles of the corresponding document [5]).
- Fitness with Constructor Institute culture.

In the case of computer science and software engineering programs, Constructor Institute shall make every effort to avoid strict requirements of previous programming experience and (for master programs) shall consider applicants with a Bachelor degree in a different field, such as mathematics, providing a valuable intellectual background. (As discussed in the Equality Guidelines [5], such strict requirements have been demonstratively shown to work against female applicants and hamper equality goals.) Such applicants, if accepted, shall be provided with compensatory courses in programming.

Applications shall be evaluated regardless of financial considerations, with scholarship requests being considered separately. For outstanding applications not backed by financial means, Constructor Institute shall strive, within applicable financial constraints, to help students find sources of financing.

The admission process is managed by the Education Office. It may involve one or more interviews, conducted onsite or remotely. For master programs, at least one interview shall take place.

In line with Constructor Institute's transparency policy, documentation about course programs (such as Program Handbooks) and the admission web site shall include clear descriptions of the application process including the above evaluation criteria.

Key success factor: publishing Program Handbooks and admission criteria on the Constructor Institute's web site before the beginning of each academic year.

4.4.2 Grading system

Student grades at Constructor Institute follow the Swiss grading system: from 1, worst, to 6, best, with 4 as the passing grade; see reference [3].

The minimum increment for course grades at Constructor Institute is 0.5[8]; averages, however, can use arbitrary precision[9].

In line with Constructor Institute's transparency policy, these rules shall be part of the basic information provided to all students and available in the education part of the Constructor Institute Web site and other general information about Constructor Institute programs.

Instead of numerical grades, a course can deliver a binary Pass/No Pass grade. Such grades shall not affect the Grade Point Average of a student. Pass/No Pass grading shall normally be reserved for exceptional cases such as short block courses, seminars and courses in non-critical parts of the curriculum.

4.4.3 Grading guidelines

Grading shall be fair: designed and implemented to reward the work of students and not to favor or disfavor any category of students against another.

In line with Constructor Institute's transparency policy, grading criteria shall be made available to students at the beginning of every course, as part of the course syllabus (4.3.1) available on the course page (4.3.2).

Regardless of who performs the grading work, the course's supervising professor(s) shall be responsible for the delivered grades.

Key success factor: defining the grading system in the syllabus of each course before the start of each semester.

4.4.4 Availability of grading results

A student's course grades shall be available to the following only:

1. The teaching team for the course.
2. The student.
3. The Provost and education office.

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[8] In other words, a grade for a *course* can be 5 or 5.5, but not 5.25 (as accepted in some other Swiss institutions).

[9] In other words, a student having obtained a grade of 5 in half of the courses taken and 5.5 in the other half will have a GPA (Grade Point Average) of 5.25 in the *program*.

4. The Program Director.
5. Any external entity to whom the student has explicitly authorized releasing the information. (Typical examples are potential employers at the time of a job application, and universities to which the student is applying for further education.)

All such parties (particularly those under 1 and 5) shall be given the information on the explicit condition that it is released for their own use only, exclusive of any further distribution.

4.5 Teaching staff

4.5.1 Professors and other instructors

Teaching at Constructor Institute takes place under the leadership of professors.

The detailed description of the role and careers of professors appears in the Faculty Statute. Professors are responsible for teaching and conducting research of international standing. They pursue excellence in all their endeavors, exert responsibility towards society and the environment, and help students and junior scientists develop their own talents and potential.

In addition to professors, teaching may involve instructors as described in previous sections.

4.5.2 Teaching load

The Provost shall be responsible for ensuring a fair teaching load for professors, consistent with practice at top research universities and with the research needs of professors, particularly assistant professors under the tenure-track system. Guidelines appear in the Faculty Statute [3].

4.5.3 Course assessment

Every course with an enrollment of 10 students or more shall be subject to assessment. Assessment processes shall involve at least the following:

- About 1/3rd through the course, an informal discussion between the course leader and the students or (for large courses) their representatives shall take place to assess the progress of the course and any correctable problems.
- Towards the end of the course, a course evaluation questionnaire is to be distributed to the students enrolled in that course.

Anonymous course evaluation questionnaires follow a model available from the Education Office, approved by the Continuous Improvement Committee, including both a general part applicable to all courses and a section for adaptation to individual course and topics. Questionnaires are processed by the Education Office.

Numerical assessments follow a scale of 1 to 5. As explained to the students filling questionnaires, 1 means unacceptable, 2 – bad quality, 3 – mediocre, 4 – good, 5 – excellent.

If a course receives an overall evaluation of 3 or less, the Provost shall set up a personal discussion with the supervising professor, following which the supervising professor shall write to the Provost a letter explaining the reasons for the disappointing results and detailing the measures to be taken to improve the course in the future.

If the assessment of the discussion is that there is no serious hope for improvement, or if the next iteration of the course takes place with the same supervising professor and shows no major improvement, the Provost shall assign a new supervising professor or take other action to restore the quality of the course.

The annual Round Tables shall also offer students the opportunity to discuss any major issues related to their courses.

4.5.4 Faculty career progression

The Faculty Statute [3] contains guidelines on how to advise and assess professors in the pursuit of successful careers.

4.5.5 Faculty hiring cycle

Initiatives for faculty hiring are the responsibility of the Provost, with approval from the President. Other members of Constructor may approach them with suggestions. As described in the Faculty Statute [3], final hiring decisions shall be subject to approval by the Board of Directors.

The President and Provost shall jointly maintain a Faculty Development Strategic Plan (FDSP) describing:

- Strengths and weaknesses of the current Constructor Institute faculty viewed as a whole, including coverage of various scientific areas of interest to Constructor Institute.
- Balance between tenure-track and tenured faculty, adjunct professors, external instructors.
- Areas of needed development, for example strategically promising new areas.
- Multi-year hiring plan.
- Short-term hiring goals at all levels (assistant and associate/full professors).

The Provost shall present to the Board of Directors, by May 15 of every year, the current FDSP including proposals for hiring in the next academic year. After possible discussions with the Provost and President, the Board of Directors shall approve or amend the yearly faculty hiring plan by September 15, to start the hiring campaign shortly thereafter. This schedule enables Constructor Institute to follow the international (notably, US) standard cycle of faculty hiring in world-class research universities. (Roughly: announcements in early Fall[10]; application deadlines around early January; interviews in the early Spring, followed by decisions mid or late Spring in time for the next academic year.)

The yearly hiring cycle is a general framework only and does not preclude hiring faculty at other times if opportunities arise ("opportunistic hiring").

Any description of proposed faculty positions, for example appearing in the FDSP, shall take the form of a "Faculty Position Paper" including: research and teaching area of proposed position; reason for proposing it and relationship with areas currently covered in the chairs of Constructor Institute; expected level (one or more of assistant, associate or full professor); place of the position in the long-term plans as described in the FDSP; examples of such positions at other universities; examples of members of other institutions who would (hypothetically) fit the position; proposed faculty search committee; timeline for the hiring.

Mechanisms for spotting attractive faculty members (including search committees) and making faculty hiring decisions (interviews etc.) are described in the Faculty Statute [3].

[10] "Fall" and other seasons refer to the Northern hemisphere.

4.6 Learning resources and student support

Constructor Institute shall maintain a set of state-of-the-art facilities, both virtual (software) and material, as well as associated staff, to support the innovative hybrid flip-learning teaching mode described in section 4.3. These facilities shall, as a minimum, include the following:

- A recording studio for recording lectures and MOOCs[11] using high-quality, state-of-the-art equipment and software. (If not on Constructor Institute premises, the studio shall be easily accessible, at short notice and minimum hassle, to Constructor Institute faculty and instructors.)
- High-quality, readily available supplementary equipment (such as microphones, loudspeakers and classroom projection devices).
- Tools for publishing lectures and lecture recordings on the Web.
- Any subscriptions, maintained up to date, to necessary videoconferencing services.
- Competent staff to help with recording and distribution.
- Tools and supporting personnel for quick creation and updates of course pages and other pages needed for education and research, with direct editing by the responsible professors and their authorized delegates.

The above resources are directed towards education. In addition, Constructor Institute shall provide the following research support (non-restrictive list):

- Subscriptions to standard collaborative publication tools (such as Overleaf).
- Subscriptions to key online library resources (such as ACM, IEEE, Springer).
- Mechanisms for quick purchase of scientific books within approved budgets.

4.7 Information management

The handling of student information shall follow all European privacy and confidentiality guidelines. Constructor Institute undertakes all reasonable efforts to ensure that student data is available only as specified in this Handbook and other Constructor Institute guidelines.

Course data on past and current students and applicants is available only under the rules of section 4.3.7.

Constructor Institute shall continuously monitor the quality of its educational efforts. Some of its chairs have a long-running experience in computer science education research (see [14] for a record extending until 2019), continuing today (with a PhD in progress on the topic). All data collected in such work, and more generally in systematic assessments of student progression and learning outcomes, shall be made available to the scientific community to the extent compatible with rules on maintaining student privacy, and contribute to the periodic review process of the programs, with active student involvement.

4.8 Public information

Every Constructor Institute document shall come with an indication of its publicity status, one of: public; Constructor Institute members only (on Intranet); specific recipients only (with case-by-case approval). In the interest of openness and transparency, all documents that do not include sensitive or proprietary Constructor Institute information shall have the “public” status.

[11] Online courses recorded on video. (The acronym means “Massive Open Online Course”.)

Students shall receive information on the study programs in the Program Handbook, made publicly available before the start of each academic year.

Research at Constructor Institute shall follow the general rules of the scientific method, as described in the Code of Academic Ethics.

4.9 Ongoing monitoring and periodic review of programs

Constructor Institute shall maintain a Continuous Improvement Committee consisting of:

- The President and the Provost.
- At least one other member from the Academic Senate.
- At least one student.
- At least one non-professor researcher.
- At least one administrative staff member.
- Any other volunteers from Constructor Institute, subject to approval by the Provost.

Terms on the Continuous Improvement Committee shall be of two years (subject to termination if a member leaves Constructor Institute), renewable.

The Continuous Improvement Committee shall conduct continuous critical examination of Constructor Institute processes and results and their quality, with particular emphasis on the quality of educational programs. The President and Provost are responsible for ensuring that the Committee has access to all necessary information and data.

The Continuous Improvement Committee shall periodically report to the Provost and Academic Senate on its activities and any identified quality-related issues. It shall hold an annual meeting in June to report its quality assessment to the President and a representative of the Board of Directors.

The Continuous Improvement Committee shall define its own operating rules in its initial sessions, and revise them whenever needed, by to a majority of 2/3rd of its members. These rules shall be designed so as to be in line with those of the Academic Senate (as discussed in the Faculty Statute [3]; in particular, decisions on ordinary matters shall be by a simple majority of the Continuous Improvement Committee representing at least 2/3rd of its members. They shall include appropriate provisions to handle any conflicts of interest, arising for example when the Continuous Improvement Committee performs a review of a program designed or managed by one of its members.

4.10 Cyclical external quality assurance

At a fixed periodicity (of 7 years or less) defined by the Academic Senate, Constructor Institute shall submit the totality of its academic processes to review by an external committee. The committee shall be composed of at least two professors from top universities, plus any other independent members whose opinion may be useful. The Provost and President shall be responsible for convening the committee, relying if necessary on reputable professional organizations such as Informatics Europe, Eqanie or accreditation councils. The composition of the committee shall be subject to approval by both the Academic Council and the Board of Directors.

Key success factor: utilizing the findings as input for the timely implementation of all potential improvements during the periodic program review.

5. References

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[2] Constructor Institute: *Development Plan*, Report CI-2023-009-EGU, 2023.

[3] Constructor Institute: *Faculty Statute*, Report CI-2023-015-FST, 2022, revised 2023.

[4] Constructor Institute: *Organization and Governance*, Report CI-2023-003-OGO, 2023.

[5] Constructor Institute: *Equality Guidelines*, Report CI-2023-009-EGU, 2023.

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