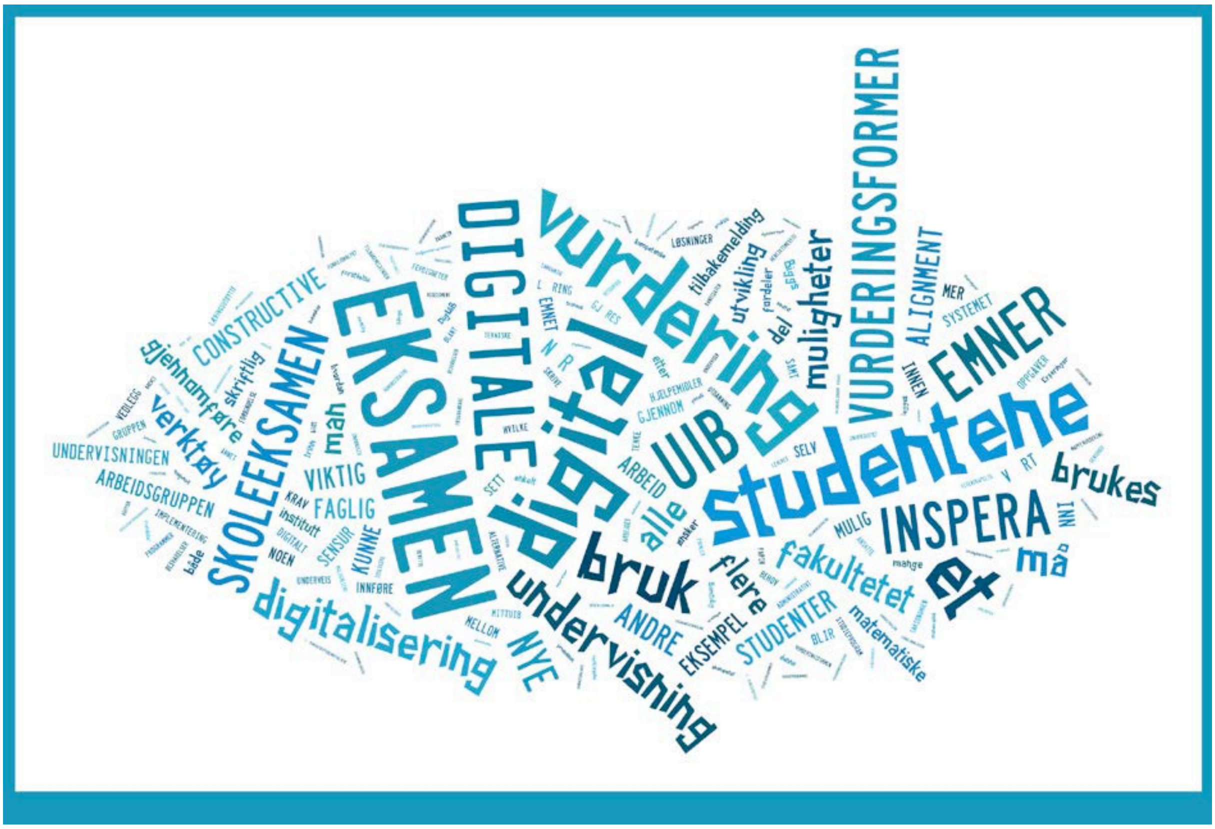
Report from the Working Group for Digital Education and Assessment at the Faculty of Mathematics and Natural Sciences



Members of the Working Group:

Professor Sigmund Selberg, Department of Mathematics (Head)
Associate Professor Mette Susanne Andresen, Department of Mathematics
Associate Professor Christian Jørgensen, Department of Biology
Professor Øyvind Ytrehud, Department of Informatics
Kjell Raymond Olsen, Student Representative
Executive Officer Magnus Svendsen Nerheim, Department of Biology (from 01.04.2016: Project Manager for DigUiB – Digital Assessment)
Birthe Gjerdevik, Faculty Administration (Secretary)

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1 Summary

University of Bergen's strategy for 2016-2022, entitled "Ocean – Life – Society", emphasises UiB's goal to become a leader in the field of new and innovative teaching and learning methods. The goal of the digitisation programme DigUiB is to ensure that all academic and administrative routines associated with examination procedures assessments will become fully digitised. By 2017, UiB shall offer technical and administrative solutions for digital assessments, which are academically and educationally anchored, and in accordance with instructional methods and desired learning outcome.

The Faculty of Mathematics and Natural Sciences also emphasises digitisation for greater study programme quality, and highlights this in its strategy (2016-2022) under the heading "Improve the quality of instruction, and increase learning outcome", stating that the Faculty must "build on new learning research and utilise digital options for instruction".

There are certain technical and academic challenges associated with digitisation of written exams, especially for mathematics and natural science disciplines (MS subjects), e.g. regarding the need to write down mathematical formulas and draw figures. These needs are currently not being met by the Inspera Assessment system, which UiB has chosen to use as its platform for digital assessment. Furthermore, it is unclear whether this requested functionality will be made available, although work in this area is underway.

It is therefore unrealistic to assume that it will be possible to achieve the goal of full digitisation of written school exams in all MS subjects in the near future.

Nevertheless, the Working Group believes that partial digitisation may be soon become possible for certain subjects, however students must continue, for a time, to submit their answers using pen and paper. In this case, answers would be scanned once the exams are completed, but all further administration and marking would be digital, which would save time and simplify the process.

However, even if the technical challenges associated with the use of subject-specific third party software in Inspera are solved, this does not mean that current written exams can or should be converted to a fully digital format.

Further work on the implementation of subject-specific digital tools for curricula and topics is needed before it would be expedient to use them for assessments. Students must first learn to master the use of these tools before taking exams, which in practice means that these tools must be utilised throughout the course of study in the various subjects.

Thorough efforts towards digitisation are required over time to ensure academically sound solutions. Here it is essential to view the study programmes and subjects as a whole, with focus on the improvement of the programme quality and the learning environment. Hasty and haphazard solutions, such as the exaggerated use of multiple choice tasks, must be avoided.

The Working Group emphasises that instruction, assessment methods and learning activities must be viewed as a whole, in accordance with the principles of Biggs' "constructive alignment" (Biggs and Tang, 2011).

2 Introduction

2.1 Basis for the Working Group and report

The University of Bergen's strategy for 2016-2022 states that digitisation and the use of new technology promotes innovation in the areas of research, education, communication, management and administration, and provides new groups in society with greater access to the University's knowledge and comprehensive collections. UiB websites and web-based services will therefore be further developed for better communication with the public, employees and students. Administrative resources will also be freed for other purposes at UiB, by introducing digital work processes with a high level of user friendliness and accessibility. UiB has been working towards the implementation of digital exams since 2014, as part of the digitisation process, and the objective is to ensure that all school exams are digital by 2017. The program DigUiB is the University of Bergen's initiative for new digital solutions for education and communication.

The 2016-2022 strategy for the Faculty of Mathematics and Natural Sciences also emphasises digitisation, highlighting this under the heading "Improve the quality of instruction, and increase learning outcome", stating that the Faculty must "build on new learning research and utilise digital options for instruction".

One of the measures proposed by the Working Group for the study programme and research education in the administrative development project at the Faculty of Mathematics and Natural Sciences (2014-2015) was to establish a working group for digital assessment. The purpose of this group was to increase the knowledge and utilisation of digital assessments. The group would also establish the foundation for the development of good academic teaching methods and assessments in a digital setting. At the Solstrand Meeting, 16-17 February 2015, where all administrative personnel were gathered to discuss the project, efforts were made to address this initiative, with a proposed mandate for the Working Group.

2.2 Mandate/scope of the mandate

The Working Group was established with the following mandate by the Academic Board on 21/05/2015. The Group was also asked to assess whether this mandate should be expanded or concretised.

> *Introduction*
> *The assessment method for a subject is naturally closely related to the method of instruction for the subject. The Working Group's mandate reflects this, and a mandate has been issued for a holistic view of students' completion of a subject, using digital and "analogue" solutions in instruction. Completing a subject must be viewed as a process, where the goal is to motivate the student to work consistently throughout the semester, and where the objective of instruction and assessment methods is to enable the student to acquire the desired knowledge, to test themselves throughout this process in a suitable manner, and to undergo a final assessment in a similarly suitable manner.*
>
> *The Working Group shall:*
>
> - *Evaluate the current use of digital instruction and assessment methods for MS*

subjects in the world around us:
  - *locally at the Faculty of Mathematics and Natural Sciences*
  - *at other universities and university colleges, both national and international*
  - *in modern upper secondary schools, such as the Nordahl Grieg School.*
- *Evaluate the interest in the future use of, and need for digital instruction and assessment at the Faculty of Mathematics and Natural Sciences.*
- *Assess the extent to which exam regulations may limit the implementation of new digital assessment methods, and identify conflict areas and the opportunities to adapt exam regulations to an electronic assessment system.*
- *Propose mechanisms for the advancement of best practice in this area to academic environments that have not yet begun to utilise digital instruction and assessment methods.*
- *Propose academically adapted mechanisms for the introduction of digital instruction and assessment to local academic environments.*
- *Assess the financial and resource-oriented consequences of converting to digital instruction and assessment.*

2.2.1 Mandate scope and specifications

At its first meeting, the Group agreed to make some minor changes to the mandate and its specifications.

The Group wished to view instruction and assessment as a whole, since these two factors are, and should be, closely related. Furthermore, the Group wished to focus on the relevancy of assessment and instruction for students' later occupations and careers.

A basic essential task is to learn what we can do to improve instruction and assessment. Transitioning to digital exams would be inopportune if the resulting exam system functions worse than the current one.

The Group chose to avoid spending time on a lengthy evaluation of the financial and resource-oriented consequences of transitioning to digital instruction and assessments, as an evaluation of this sort would be too extensive, would be outside the area of competence for the Group members.

2.2.2 Group tasks

The Working Group has had five meetings, in addition to email correspondence. In the second meeting on 2/2/2016, the Group invited Robert Gray and Arild Raaheim from the Department of Education, to speak on the subject of digital instruction and assessment. They talked about the use of LMS (Learning Management System, e.g. My UiB), and about the new assessment methods and digitisation. The Group obtained information and feedback from the departments of the Faculty of Mathematics and Natural Sciences, and from other sources, as needed.

3 Relationship between instruction and the exam

Compared with exam methods currently being used, digital assessments offer new opportunities, as well as some limitations. It is therefore important to carefully consider what digital assessment methods would actually test, compared with more traditional examination methods used for each subject. This provides an opportunity to make the most of the effort invested in the production of tasks and assessments, so that the exams can more precisely test the skills that the University wants the students to acquire. At the same time, the exam process, student assessments and any feedback received would all provide learning opportunities.

NOKUT (Norwegian Agency for Quality Assurance in Education) is observing developments of the EU and the Bologna process, which require learning outcome in all higher education subjects to be structured based on the “knowledge”, “skills” and “general competence” acquired by students in these subjects. This reflects Biggs’ focus on congruence between what one wants the student to achieve, and what the student is tested on in the exam (“constructive alignment”, Biggs and Tang 2011), and draws upon Bloom’s cognitive taxonomy (Bloom et al., 1956) which describes the processes of understanding across different levels, from “surface” to “deep”. One fundamental problem of the exam is that it is simpler to test “knowledge” than the more complex application of this knowledge through “skills” and “general competence”. One of the most well-known instruments for achieving congruence between learning goals, instruction and assessment is called “constructive alignment” (see 3.1). The transition to new assessment technology also involves a few practical challenges which may have an impact on instruction in today’s subjects (see 3.2).

3.1 Constructive alignment

A widely known and frequently used classic text regarding basic concepts and relationships in higher education is Biggs’ model of “constructive alignment” (see Biggs and Tang 2011, Biggs 1996). The basic premise of the model is to apply the most important principles of constructivist learning theory to actions and decisions with respect to instruction and assessment.

One of the major points of the model is to have a suitable congruence or alignment between the intended learning outcomes, the various teaching and learning activities students are involved in, and the assessments of the students (Figure 1).

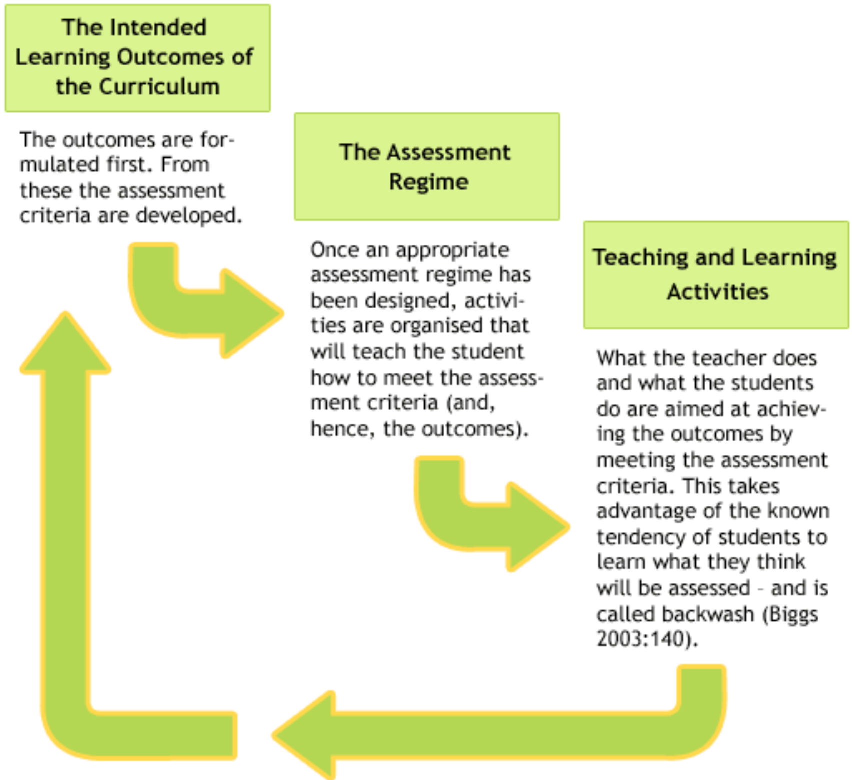

Figure 1. Model indicating the three key areas of **Constructive alignment**

Ideally, this alignment should be evident at several levels: not only within each individual subject, but also with respect to the composition of subjects in the study programme. This basic principle has been included in both the Bologna process and in Norway, operationalised through NOKUT's requirement for including descriptions of learning outcomes in Norwegian study programmes and for individual subjects. This may be viewed as a process, starting with a critical review of the learning outcome for each study programme, followed by a composition of subjects which are then adjusted, so that the sum of learning outcomes for the subjects underpins and corresponds with the intended learning outcomes of the study programme. This is, in practice, an iterative process, where both subjects and curricula are more or less revised on a regular basis. One potential problem is that subjects are revised in step with academic developments in the field, causing us to lose sight of the study programme's coherent whole. This may lead to overlapping and gaps between subjects. Another possible challenge is that certain important competencies we want students to master after completing a study programme, such as the capacity for analytical thought, an understanding of tables and graphs, writing skills, verbal communication, etc., are taught to a varying extent across the different subjects, perhaps even insufficiently with respect to study programme objectives. By placing more emphasis on the study programme's learning outcomes, it would be easier to determine the progress of these key skills in a more comprehensive manner, across subjects, so that students would encounter progressively greater challenges throughout the course of study.

When working with the coherent whole, it is also essential to consider the roles of exams and assessments. Unfortunately, it is still the case that assessment methods used for a subject often test something other than the intended learning outcomes. As Biggs points out, students will generally prepare themselves for the exam by studying the content indicated by the type of exam they are taking, and will therefore often be left with a different and a narrower understanding of the subject matter than that which is expected for further studies and careers. A prudent alternative to more traditional exams used for the assessment of a subject will often prompt students to study subject matter that is more targeted towards the intended learning outcome. There is a wide array of alternative assessment methods (see Raaheim (2016) and Attachment 1), and most of them are permitted in accordance with UiB regulations (see 4.4).

SOLO Taxonomy (Structure of Observed Learning Outcome, see Biggs and Collis, 1982) is generally associated with the use of in Biggs' model of constructive alignment. SOLO taxonomy is intended to assess what students have gained from instruction, and not the instruction itself (in contrast with Bloom's taxonomy, which is often used for both, in practice).

SOLO Taxonomy is comprised of five progressive levels of understanding, where each level depends and relies on the previous level (Table 1).

Table 1: The five progressive levels of understanding in SOLO Taxonomy

	What is required of the student	**Additional requirements**	**Deficiencies at this level**
Level 1 Prestructural – The task is not attacked appropriately; the student hasn't really understood the point and uses too simple a way of going about it.	The student's understanding appears to be composed of disjointed information.		
Level 2 Unistructural – The student's response only focuses on one relevant aspect	The student can identify, rephrase, and apply certain procedures,		but masters only certain aspects
Level 3 Multistructural – The student's response focuses on several relevant aspects but they are treated independently and additively. Assessment of this level is primarily quantitative	The student can list, describe, combine,	and master several aspects,	but does not integrate them into a whole.
Level 4 Relational – The different aspects have become integrated into a coherent whole. This level is what is normally meant by an adequate understanding of some topic	The student can compare, contrast, explain causes, analyse, relate, apply,	and master as well as integrate several aspects into a whole.	
Level 5 Extended abstract – The previous integrated whole may be conceptualised at a higher level of abstraction and generalised to a new topic or area.	The student can theorise, generalise, form hypotheses, gain perspectives,	and shift from the specific to the abstract.	

With respect to the use of digital tools, Biggs' model, combined with SOLO Taxonomy can be applied in the following manner: The desired or intended learning outcome for a subject is formulated with the use of SOLO Taxonomy levels, and the assessment method is thereafter determined accordingly. Each level of the taxonomy is naturally associated with different methods of assessment. Understanding at levels 1-3, for instance, are often either entirely or partially assessed by simple multiple choice tasks, while understanding at levels 3-4 normally require dialogue and/or extended explanations (concise written or oral tests), and understanding at level 5 is traditionally assessed by lengthier written work. In this context, digital tools play an important role. The implementation of digital tools for instruction and assessment is a clear and appropriate opportunity to discuss and possibly rethink the academic possibilities of various tools.

The model of constructive alignment, combined with SOLO Taxonomy, may be viewed as an easily accessible and simple starting point for the work involved in adapting and evaluating instruction at all levels and in all academic areas. Critics have stated that research-based instruction at a university level, meant to promote critical and creative thinking, as well as to provide new knowledge, is inadequate. It is clearly challenging to formulate learning outcome descriptions for advanced subjects in higher education. If one were to specify the knowledge students are expected to acquire, it may be difficult, at the same time, to simultaneously encourage particularly creative students who are independent thinkers (Andersen 2010). This is a group the university should take care to cultivate, and when formulating descriptions for learning outcome descriptions, it is therefore important to include loose and general formulations that allow for reflection and criticism. Examples of such learning outcomes might include: "be critical of the methods taught in the course, and be able to discuss their strengths, weaknesses and possible alternatives", and "utilise concepts, theories and perspectives from the course to discuss socially relevant topics or scientific issues". These learning outcomes would allow for critical thought with respect to both the subject and lecturers, while also offering the student the opportunity to demonstrate highly relevant skills that could result in favourable marks on the exam.

3.2 Digital exam tools call for student training and changes in instruction

Constructive alignment is of equal importance for the implementation of digital tools used to assess what students have gained from instruction. For instance, if instruction has spent a great deal of time and effort on certain aspects of the academic content, and the assessment suddenly requires students to utilise a relatively unfamiliar technology, there would be a lack of sufficient congruence. And vice versa, if students who are accustomed to having various digital tools at their disposal as an incorporated part of their academic preparations are then deprived of these tools during the exam, this would also be an example of insufficient congruence. Take for instance mathematics students who have become accustomed to gaining a visual overview of an assignment with the aid of graphic tools, and who are then deprived of these tools during the exam and must analyse their way to the answer using other methods. There are two aspects that are particularly important to consider when using digital or other new tools in instruction and assessment, regardless of subject or level:

1) Experience has shown that learning to use new tools can often be a more extensive and

time-consuming process than previously expected. For a teacher to succeed, sufficient time must be set aside to plan and prepare an instructional plan that at least partially focuses on the use and possibilities of the tool. It would be expedient to closely relate this plan to the academic content of the subject, tailoring the contents of each individual subject as much as possible. This is both to avoid spending an inordinate amount of time, and to ensure the best possible utilisation of the tool in question.

2) When a new tool is utilised within for a discipline, it becomes integrated as part of what one would call the student's "academic preparation", for better or worse. With various digital tools at one's disposal, the relevance of certain types of tasks will disappear entirely, while providing the opportunity to work with new tasks and problems. In mathematics, for instance, the assessment of certain routine skills possessed by the student would be irrelevant if the student has access to CAS tools during the exam. Tasks associated with modelling and simulation, however, may be more extensive. Problem-solving strategies and the thought processes behind them would be influenced by new possibilities made available through the use of these tools.

These two aspects are encompassed by the theory of "instrumental genesis", which is a common starting point for research on the implementation of digital tools in the teaching and learning of mathematics (see Drijvers and Gravemeijer, 2005).

3.3 Feedback for students before and after the exam

Universities spend large resources on developing and grading exam questions. For many subjects, this is the teacher's sole opportunity to view the skills of each individual student. Feedback is generally limited to one mark. An obvious way to improve the quality of the study would be to help make the exam a more important arena for learning. Feedback for students is a keyword in this context.

- Feedback may be provided during the course of study, by ensuring opportunities for assessments in the form of smaller assignments, and not just one final exam. These could be used to determine the final mark, or just be pass/fail assignments. Students could then receive feedback from teachers, teaching assistants, or from arrangements where students can comment on each other's work. In Hattie's (2009) review of learning strategies that appear to provide the best learning opportunities, it was found that student-student feedback had the greatest effect. This type of feedback also requires very little effort on the part of the teacher.
- Some assessment methods, such as oral exams, offer the opportunity for feedback during the exam. This can also be done digitally. Medical studies at the University of Oslo use digital exams which involve simultaneous marking and feedback during the exam, as well as tasks that offer new response options based on the student's answer to the previous question.

- Once the examiner has read an exam answer, and come a decision, it would involve very little extra effort to write a couple of sentences to the student, pointing out strengths, weaknesses and what the student should continue to work on in the subject and in later studies. This has been done throughout the past two years in the subject BIO100. Students have generally been very pleased with this system and have viewed the feedback as informative and useful. One problem is that the students do not always read the feedback or make use of it. A possible solution is to provide the feedback a few days before announcing the exam results. At this point most students are more eager for a reply, and will be more likely to analyse and reflect on their own performance in light of the feedback.
- Another method, which does not require writing to each student but which still offers a clear indication of what the student has achieved or is struggling with, is called "grading rubrics", where students receive a score for each learning goal, as well as a score that indicates a grade or mark, so that students can, for instance, see for themselves that they have read the material thoroughly and know the details, but are not able to draw parallels to other contents of the syllabus, or make clear arguments based on the principles of the subject. BIO100 will implement this system in autumn 2016 (see Attachment 2).

The opportunity to provide each individual student with written feedback is possible using the UiB digital systems (see 4.3). Here feedback can be given for specific assignment, or for the entire exam. Teachers should give careful thought to the kind of feedback they wish to provide, and in what form. Experience has shown that feedback functions best when students later have the opportunity show what they have learned from it. Feedback can either be based on general skills that will be important in later subjects, or the student can receive feedback for academic performance in the midterm exam, and use this in case some of the same content is presented in the final exam.

3.4 Digital competence requirements for study programmes at the Faculty

Very few workplaces do not utilise digital tools in today's society. Academia, private businesses and public services all require their employees to acquire digital competence in order to utilise current and future tools.

All students at the Faculty of Mathematics and Natural Sciences should therefore acquire the skills needed to understand and utilise digital tools and programmes during their studies. This would require a basic understanding of how digital tools and programmes are designed. It would therefore be an advantage to make programming mandatory for all undergraduate study programmes, and to offer credits for programming in graduate programmes. This is already being done at some institutions, such as NTNU. One example of a subject already being used in several Bachelor programmes is INF109 Data programming for natural sciences. The objective of this subject is to teach students to code in Python.

It is also important for students to gain an understanding of how to use subject specific tools, and to learn how these function, so that changes in technology and society will not have a negative impact on student efficiency during their education or after graduation. The need for these tools must be assessed by the respective academic environments, and implemented in both instruction and assessment methods. Examples of such programmes can be found in Attachment 3.

Other programmes can be used that overlap different subjects of a study programme, where the focus is on underlying mechanisms, in addition to practical use for instruction and assessment.

3.5 Incentives for the development of instruction

Efforts towards educational quality and instruction have traditionally been given lower priority than research, and teachers have received little acknowledgement for their efforts towards a systematic development of instruction within these programmes.

In recent years, there have been national initiatives intended to improve the quality of education by Centres for Excellence in Education. Here UiB has been represented by bioCEED.

The Faculty of Mathematics and Natural Sciences has decided to introduce a merit award system for teachers who acquire the educational competence level of Excellent Teaching Practitioner (ETP Fund). By introducing this system, the Faculty wishes to place greater focus on systematic and targeted efforts to improve the quality of education, as well as the collegial teaching culture at the Faculty.

4 Digital assessment

4.1 Advantages of digitisation

Digitisation offers certain benefits and new opportunities for assessment, instruction and other aspects of education. Since the transition to digital exams often requires the exam to be carried out differently than previous exams, this offers a golden opportunity to reflect on the reason for implementing a certain exam method, what the exam actually tests, and how the exam can be considered an integral part of the subject and the learning outcome descriptions. It is essential to give thorough consideration to the strengths and weaknesses of the various examination methods, the practices of the institution, as well as teaching and assessment theories and the relationship between them.

4.1.1 Advantages of digitisation from an academic perspective

If we can disregard the technical and instructional challenges presented by the transition to digital exams, it becomes clear that digitisation presents for new opportunities in comparison with traditional pen and paper exams, which can be an advantage to both teachers and students.

Teachers are given the opportunity to test out new types of exam assignments, and gain new perspectives on learning and assessment. Exam grading may be simplified (and sources of error eliminated) by improving readability, since handwriting would no longer be an issue, and digital grading can (partially) be carried out for both multiple-choice questions and far more advanced assignments, such as the use of flexible CAS-based tools to check mathematical answers. In addition to the introduction of digital learning platforms, this offers new opportunities for teachers in terms of subject design, instruction and assessment. A digitisation process can therefore provide a golden opportunity for a critical review of our subjects and study programmes, by creating a comprehensive learning environment, where instruction, student learning activities and assessments all adhere to the principles of constructive alignment (see 3.1), and take into account the realities that our graduates will face in their careers (see 3.4).

Students may experience exams as more meaningful and motivating if exams test their knowledge, skills and competencies in a more precise manner as determined by the learning objectives. Digitisation also offers greater possibilities than traditional pen and paper exams. For instance, students would be able to compile and test programming codes during the exam instead of simply writing them down, using software for statistical analysis of data and solving mathematical problems numerically.

One possibility for integrating testing with instruction is to develop an assignment bank, where previous exam assignments are made available to students, so that they can prepare themselves. These assignments can also be used actively in instruction. It would also be possible to post exam answers by previous students, as well as the feedback they were given, so that students can compare their own answers with those of others and see the feedback they received. In Hattie’s (2009) meta-analysis of learning strategies, providing a grade or a mark offers significant learning benefits, since this can also be integrated with an assignment bank, e.g. after a student has compared his or her answers with answers that have been graded with letter marks from A through F, accompanied by an examiner’s explanations.

4.1.2 Advantages of digitisation from an administrative perspective

There are several benefits of digitisation from an administrative perspective. It is possible to view long-term financial benefits of implementing digital process flow and streamlining work processes, including a reduction of manual tasks, which in turn would reduce the risk of manual errors (see the report on digital exams at NTNU, 2015).

One clear advantage of digitisation is that the exam itself can be taken on a computer, while the digitisation of the exam process can also be performed for subjects that do not involve digital exams. There are advantages with respect to grading/marking and digitisation of records for various subjects. For subjects that involve submission of assignments, oral exams, pen and paper exams, etc., grading and marking can be performed digitally.

For subjects with assessment methods that involve uploading of digital versions of exam answers, either through electronic submissions of assignments or by scanning pen and paper answers, examiners will receive the exam answer electronically and have the opportunity to compare their grading decisions with other examiners. Digitisation also enables the digital archiving of exam answers, which reduces the need for physical archives, and facilitates a simpler administration of complaints regarding exam results.

Digital grading and marking, with write-back to the student database will increase security by reducing the number of manual steps and error sources associated with these. It will also entail a shorter waiting period for students to receive their marks, and remove the need for a physical archive for exam records.

4.1.3 Digitisation from a student perspective

Students at the Faculty of Mathematics and Natural Sciences are especially concerned that the digitisation should not be done just for the sake of digitisation. It is essential that the digitisation process be used to adapt assessment methods to suit a study situation that stimulates learning and that is relevant for work after graduation. This can be maintained by ensuring that digital exams are not reduced to multiple-choice questions and essays. Efforts must be made to utilise the system's compatibility with third-party programs and other functions, to provide students with the opportunity to acquire knowledge and digital skills needed for their future careers.

Students also believe that it is important that the infrastructure is in order, and that this does not negatively affect normal academic life more than the current written exams do. They mention such things as closing study halls for the implementation of (digital) exams outside the ordinary exam period. Students understand that this responsibility lies primarily with the Division of Student Affairs (SA), but have noted that the Faculty itself can play a more significant role in planning and room use.

Students wish to emphasise that individual course coordinators should have a responsibility for adapting both the subject and the assessment method to keep in step with the development of a fully digitised university. It is essential that the student does not participate in an exam utilising third-party programs that are not associated with instruction. This also means that the course coordinator should examine third-party programs to provide students with the best possible learning and assessment outcomes, not just for the final exam, but for the intended learning outcomes for the entire subject. Students have a positive attitude towards the current development, and would prefer digital exams wherever they are most expedient.

4.2 The need for functionality in digital exams

The Working Group has sent out a letter to all departments at the Faculty regarding the need for functionality and programs required to implement digital exams for subjects that currently use written exams. This report includes a brief summary of the feedback from the departments. See Attachment 3 for more detailed comments.

Comments from the departments can be summed up in the following manner.

In addition to the current functionality present in systems for digital exams, there would be a need to:

Write

- mathematical formulas and symbols
- programming codes, and compile these
- chemical formulas
- lengthier mathematical calculations and derivations. It must be possible to write answers that primarily consist of mathematical expressions just as efficiently as handwriting on paper.

Use

- digital drawing tools
- software to create molecule structures and draw reaction mechanisms
- third-party programs, e.g. spreadsheets (Excel), R., MATLAB and Python

Furthermore, it is preferred that:

- the tools are user-friendly, and that students receive training in the use of these tools prior to exams
- the tools provide documents with good readability on all platforms used by students during the exams, and by examiners during evaluation (and future readability must be ensured for digital archiving)
- efforts are made to ensure that all functions and routines are designed to reduce manual steps which involve a great deal of effort and can result in errors.
- all functions such as formulas and illustrations can be easily inserted into exam questions and directly into student answers.

4.3 Digital assessment at UiB – current situation and future plans

DigUiB is the University of Bergen initiative for new digital solutions. The project was launched in 2014. DigUiB develops, tests and implements digital support systems and tools for education and communication. The program currently has three main projects: digital assessment, a new learning platform, and a digital learning and communication lab.

The project group for digital assessment is making efforts to implement routines and to and test systems for digitisation of assessment processes and examinations at UiB.

4.3.1 Digital school examination

Since 2014, the UiB has been working towards the implementation of digital school exams. Implementation began in spring 2015, and by the end of 2015, 48% (measured in number of students) of all UiB school exams were digital. By spring 2016, 55% of all school exams were digital. UiB's goal is to ensure that all school exams are digital by 2017.

At the Faculty of Mathematics and Natural Sciences, 6 out of 8 departments use digital school exams in one or more subjects. In spring semester 2015, 7 subjects used digital exams. In fall semester 2015, 25 subjects used digital exams, and in spring semester 2016, 25 subjects used digital exams (some subjects have several partial exams, altogether 41 individual exams). The Department of Molecular Biology and the Department of Biology are the two departments with the largest share of digital school exams. Most of the subjects that have not had digital exams rely on a functionality which is not present in today's digital examination solutions, such as the opportunity to write mathematical and chemical formulas.

4.3.2 Inspera Assessment

UiB has selected the system Inspera Assessment (Inspera) as a platform for digital assessment.

Inspera is primarily used for written school exams, but can also be used for submission of different types of assignments and home exams. The student would then upload a file from their own computer. The file format for exam answers can be specified.

When the system is used for school exams, students bring their own laptops. Prior to the exam, they must download a secure browser (Safe Exam Browser, SEB). SEB prevents all access to other programs and the internet, and students will only have access to the exam assignment during the exam.

Inspera currently offers several types of school exams:

Multiple-choice tests present the student with several different response options, where one or more of the responses may be correct. Points for correct and incorrect answers are noted when the test is registered in Inspera, and the total sum is calculated automatically once the test has been graded and marked.

Long answer tests require the student to respond by writing text in a text editing program. It is possible to use some symbols which can be inserted into the text, however this functionality is not suited for exams that involve the need to write many formulas.

Programming tests require the student to respond by writing a programming code in a predefined programming language. The student responds in a code editor window, which automatically formats the text into correct syntax for the defined language. Inspera Assessment supports syntax for over 50 programming languages. It is not possible to compile or run codes.

Fill in text – the student enters a word or short sentence in a text field.
Dropdown – the student is presented with several response options in a dropdown menu, but only one is correct.
True/false – the student is presented with two response options, where one is correct. The alternatives are presented in a list.
Pairing – is a more complex version of the multiple-choice test. Pairing consists of a table with an optional number of rows and columns.
Drag and drop – a certain number of drag elements are dragged to a predefined drop field. The drag elements can include images and/or text.
Selection field – with the aid of instruction, students must determine the correct answer by clicking on the correct spot in a picture or illustration. It is possible to click anywhere on the picture, and the mark will appear as an X.

More information about types of exams can be found at:
http://www.inspera.no/?siteNodeId=1322664

The Faculty of Mathematics and Natural Sciences has used all the Inspera tests for written school exams (primarily multiple-choice, long answer and programming code), as well as for submission of term papers and completion of home exams (both file uploading and answers typed directly in a browser).

Inspera has not yet adapted its tests to allow students to draw detailed illustrations in their exam responses. The current solution is to have students submit paper attachments which are then scanned and added to the students' responses in Inspera. According to DigUiB, efforts are underway to provide solutions for the digitisation of illustrations/hand-drawn sketches, either with the use of direct digital solutions (e.g. digital pens or drawing pads), or by the digitisation of analogue drawings. The opportunity for third-party programs in Inspera have been proposed as an area of development, however, it is not known when such functionality will be ready for use.

4.3.3 Mitt UiB (My UiB)

"Mitt UiB" (My UiB) is the University of Bergen's new learning platform (LMS). It was implemented by the Faculty of Mathematics and Natural Sciences during spring semester 2016. While "Mi Side" (My Page) was an administrative platform with few opportunities to involve students, or promote learning development, Mitt UiB is a learning platform that offers many opportunities. Most the functions in Mi Side have been retained and also adapted for numerous possibilities for alternative learning methods, assessment methods, etc. At the moment, there are no clear guidelines to identify situations where Mitt UiB and Inspera should be utilised for instruction and assessment, but the rule of thumb during the implementation phase has been to submit all material to be marked and graded (or that will be part of a grading process).

It would be desirable to achieve the maximum potential offered by Mitt UiB with respect to alternative instruction and assessment methods. Among other things, Mitt UiB is easily integrated with third-party programs, such as the math program Maple TA, as well as programs that can offer flipped classrooms.

It is too early in the implementation process to determine the size of the Mitt UiB catchment area, but the opportunities for new perspectives on student learning based on the principle of constructive alignment, are obvious.

It is essential to ensure that Mitt UiB and Inspera are well-integrated, and to have a clear description of the parts of the assessment that can be performed via Mitt UiB, so that it does not conflict with students' demand for secure assessment and feedback. This type of connection would enable the realisation of the potential and possibilities inherent in these systems, and ensure that they are used in the most optimal manner with respect to digitisation of existing assessment methods, as well as the development, testing and implementation of new assessment methods.

4.3.4 Use of alternative methods for digital assessments

As well as being an arena for digital school exams, UiB's current technical solutions (primarily Inspera and Mitt UiB, and others) enable the use of several other digital assessment methods. In his book, "The Exam Revolution" (2015), Arild Raaheim, Professor of Education at the UiB, lists 40 different exam methods that can be used as alternatives to traditional school exams (Raaheim 2015). These exam methods range from variations on school exams, to oral exams and other assessment methods (Attachment 1). UiB's technical solutions have already been adapted to permit a majority of these assessment methods, and everything is technically in place for an increased use of digital assessment and alternative digital assessment methods.

4.4 Rules and regulations

There are regulations relating to admission, academic studies, assessment and grading at the University of Bergen that provide the foundation for all assessments performed at the UiB, including several relevant provisions.

Section 6. Relating to examinations/assessments:
During the most recent revision of the UiB regulations in November 2015, Section 6.2.2, involving school exams, specified that written school exams should primarily be taken digitally, but that they could also be taken using pen and paper.

Section 6.2.1 relates to assessment methods, and subsection 1 lists 13 specific exam methods that can be used at UiB:

(1) At the University of Bergen, the following assessment methods may be used:
a) written school exam
b) oral exam
c) home exam
d) portfolio assessment
e) supervised assignments and non-supervised assignments, including bachelor's or master's thesis
f) trial lecture
g) passing mark based on attendance
h) production
i) concerts
j) lab reports
k) practice training
l) clinical test with field work/excursion

(2) It may be determined whether an assessment method should be used on its own, or in combination with others. The curriculum or subject descriptions will state which of these assessment methods will be included in the assessment scheme for a subject. If the assessment method can or shall be performed as a group assessment, this must be specified in the curriculum.

Digital school exams are listed under written school exams. Alternative assessment methods usually fall under the collective term "portfolio assessment". Subsection 2 enables the use of a combination of assessment forms. Together with Section 6.2.2, this section has been revised to include digital assessments, but could have been more specific.

In an earlier revision of UiB regulations, the Faculty requested that regulations permit new assessment methods to be approved by the Faculty, as it is difficult to predict which assessment methods may be relevant, e.g. for bioCEED (Centre for Excellence in Biology Education). This has not been included in the regulations, although UiB does have a strong focus on the increased use of alternative assessment methods.

Section 6.5 involves the use of tools or aids during exams. Regulations state, in general terms, that the Faculty is required to control their use, however this does not limit the use of digital assessment methods.

Section 6.13.1 relates to special arrangements to facilitate exams. In many cases, digital assessments can more easily be adapted for special arrangements, resulting in more equal treatment for students who have previously required special arrangements with the use of a computer, due to tendonitis, dyslexia, etc.

Section 7. Relates to evaluation and grading:

The section involving complaints and anonymity related to evaluation and grading has to a large extent been adapted to individual exams (Section 7.7 (2)). Reviewing complaints regarding exam results or marks is particularly challenging in subjects using more than one assessment method, either in the form of several exams, or as a portfolio assessment. In the case of a portfolio assessment, this can be solved by only permitting the student access to request an explanation for the mark they have received, and possibly also to complain about final marks in the subject, and not after each exam (Section 7.6 (2)).

Section 7.6 (2) relates to limits to the right of appeal.

(2) Complaints regarding the assessment of individual assignments that are part of a portfolio assessment or other ongoing assessment can generally only be submitted once the final results or marks have been posted. The Faculty can, in its subject description, determine that the complaint or appeal procedure can take place after each separate test, if the results may impede continued progression during the semester.

The regulations do not specify what is meant by an ongoing assessment. For subjects with several different tests and exams, is not clear if regulations stipulate whether complaints for grading and marking can only be submitted after all the tests and exams have been completed, or whether this only applies to subjects with portfolio assessments. In order to simplify the work on new assessment methods, there must be clear guidelines defining portfolio assessments, as well as what is included in a portfolio assessment, and what constitutes parts of an assessment for subjects without portfolio assessments.

Section 7.7 (1) Student anonymity during the grading process must be ensured to the extent it is academically and practically possible.

Anonymity during the grading process (Section 7.7) may be a challenge for subjects that involve several assessment units, as some of these may be impossible to anonymise. This may apply to subjects that have several assessment parts, such as oral presentations and written exams. There is a need to specify the way in which anonymity will be ensured for such subjects.

Efforts on the implementation of new assessment methods are impeded by the regulations, and especially by Section 7.7 (anonymity) and Section 7.5 (examiner explanations and complaints on results). Anonymity is difficult and unpractical to maintain for subjects where different assessment parts have different requirements for anonymity. Explanations and complaints in these subjects can be made after the final mark has been determined (Section 7.6 (2)), however, this would require far more work for the examiners than was previously the case, since all parts of a portfolio assessment or subjects with several partial exams must be assessed by new examiners. Experience has shown that this may cause many examiners to refuse examiner assignments, since it involves a great deal of work. A compensation scheme for a new grading process must therefore be re-evaluated if the current regulations remain in place, and increased expenses of an external grading process must be considered when transitioning to the new (digital) assessment methods. It may be necessary to consider which parts can and should be reassessed. A case is up for consideration by the UiB Education Committee on 5 September, which will involve a discussion on portfolio assessments, as well as clarifications regarding complaints about portfolio assessments. Subsequent to this meeting, and to any changes made in the regulations, the Working Group will, in autumn 2016, write an attachment to this report which will reflect the status of regulations regarding digital assessments.

It is essential that there are no unnecessary legal barriers to hinder the development of new teaching and assessment methods.

4.5 National and UiB experiences

4.5.1 Upper secondary school

Digitisation has come a long way in the upper secondary schools, relatively speaking. The use of the learning platform ("It's Learning") has been systematically employed, all students and teachers have laptops, and digital skills are incorporated in the curriculum as one of five basic skills (in addition to reading, writing, numeracy and oral skills).

The curriculum for mathematics as a basic subject includes the following about digital skills:

> *"Digital skills for mathematics involve the use of digital tools for learning through games, exploration, visualisation and presentation. It also involves the awareness, use and evaluation of digital tools for calculations, problem solving, simulation and modelling. Furthermore, this involves locating information, analysing, processing and presenting data using an appropriate tool, and maintaining a critical approach to sources, analyses and results. Development of digital skills involves working with complex digital texts, with an increasing level of complexity. It also involves greater attention to the benefits of digital tools for learning in the subject of mathematics."*

The increased use of digital tools is reflected in the framework introduced by the Norwegian Directorate for Education and Training (UDIR) in the spring of 2015. Here, requirements were introduced for the use of digital tools during math exams in upper secondary schools. For students taking Mathematics R1 and R2 (Maths, Science and Technology – MST), there are two parts to the exam. Part 1 is taken with pen and paper, while Part 2 is done with the aid of spreadsheets, graphs and CAS (Computer Algebra System), e.g. GeoGebra. The idea here is not to implement a paperless digital exam (everything will still be submitted on paper), but to introduce broader competency goals that also include problem solving with the aid of digital tools. As the use of digital tools is gradually introduced to exams, they will also be utilised for teaching mathematics in upper secondary schools. In the future, we can assume that all first year students at the Faculty of Mathematics and Natural Sciences will have a certain amount of experience using mathematics software, and are familiar with standard syntax for writing mathematical formulas on the computer.

Only mathematics will require the use of spreadsheets, CAS or graphs for exams. Other MST subjects do not require the use of digital tools during exams, and choice of tools will depend on the teacher. The exam guidelines by the Norwegian Directorate for Education and Training indicate the tools and aids that are required and permitted. For exams in Biology 2, Physics 2 and Chemistry 2, the guidelines state that part 2 of the exam should be IT-based, to the extent this is possible. For Geo subjects (Geology, Geophysics and Geography), it states that the entire exam should be IT-based, if possible. In part 2, all tools and aids are permitted apart from the internet and other tools that can be used for communication. The exam guidelines also state:

> *When using web-based tools and aids for exams, it is important to ensure that students cannot communicate with others (collaborative writing, chatting, and other opportunities for exchanging information with others) during the exam. Throughout their education in the respective subjects, students shall have received instruction in evaluating the use of tools and aids that could be an advantage for their work on various types of assignments. It is the student, often through consultation with the teacher, who must determine which tools and aids are most useful.*

4.5.2 UiO, UiA and NTNU

Like the University of Bergen, University of Oslo (UiO), University of Agder (UiA), and the Norwegian University of Science and Technology (NTNU), all have the objective of enabling digital solutions for all school exams, however the time frame for achieving this objective varies between universities. UiB, UiO and UiA have come closest to achieving this objective, while NTNU still has more work to do, and intends to meet its goal of full digitisation by 2022.

Since all the institutions are working on the same issues regarding digital assessments, and are largely using the same systems, it would be advantageous to consider economies of scale through increased cooperation and collaboration in the university and university college sectors. Currently, UiB is cooperating with UiO and UiA on the development of digital assessments, using the same system (see 4.5.4).

4.5.3 Experiences with digital exams at UiB

Digital exams have already been carried out at UiB for several semesters, and we have gained some experience in its use.

4.5.3.1 Students

DigUiB carried out a user survey among students who had taken digital exams in the spring of 2016. The general conclusion is that students are pleased with this system. At the Faculty of Mathematics and Natural Sciences, 88% stated that they would prefer digital exams again, and 90% found the exam tool Inspera to be user friendly. Students experienced an improvement in the exam situation using digital tools instead of the traditional exam, and the administration and execution of the exam functioned well, both in terms of technical control and the robustness of the system.

In some cases, changes must be made to the assessment method in order to adapt to the new system. This reduces the advantages of the exam. Students point out that it is important for the system to support assessment methods that are of greatest benefit for student learning, and that they should not be altered merely fit the system. Students hope that further development of software, the possibility of digitising sketches and drawings, and integration with third-party programs would help to solve this problem.

The introduction of the learning platform Mitt UiB (My UiB) has enabled new potential for active learning and new instruction and assessment methods. Despite a few start-up problems during the implementation phase, students feel that Mitt UiB is far better than the discontinued MiSide (My Page), and have great expectations for further use.

4.5.3.2 Experiences with the use of Inspera

Implementing Inspera as a digital exam system has led to changes in administrative roles for exams, from one exam coordinator to a host of other functions. This includes local user support, training for students and employees, technical consultants, developers and troubleshooters. All this, in addition to the use of Inspera, which is a system under development, and UiB, which is a university undergoing digital changes, has led to a few problems uncovered during the process. The majority of these problems have either been solved directly, or forwarded to Inspera via DigUiB as errors or requests for new functionalities, or local solutions have been developed. One example is the attachment sheet routine, developed for Mathematics and Natural Sciences, which meant that many subjects that were not able to use Inspera due to the lack of sketching and drawing functions, were now able to carry out digital exams. Close communication between administrative staff working with digital exams, and good cooperation with academic staff who wished to take steps towards a new solution, led to a good implementation of digital exams for a system that was gradually created through a lengthy process.

It must be noted that there has also been some frustration among both academic and administrative staff members during the process of implementing Inspera. This was associated with two primary areas: 1) the lack of communication and knowledge regarding what Inspera can and cannot do, reinforced by expectations of 100% digitisation of school exams by the end of 2016, and 2) many bugs and cumbersome solutions for task creation and evaluation of exam results, which over time created a lot of frustration.

It is clear that facilitating the sharing knowledge and experiences with the use of Inspera among administrative staff is a significant advantage. At the Faculty of Mathematics and Natural Sciences, there was at least one administrative superuser for Inspera for each department. Experiences with the use of the system have varied however, due to major differences in the number of digital exams carried out by each department. Communication and the exchange of experiences has been emphasised in the Faculty's exam forum, where administrative employees from all the departments have participated. Work halls have also been set up for academic staff, where they can collaborate on entering exam assignments into Inspera, and receive assistance from superusers as needed.

See also the DigUiB evaluation of digital exams at UiB for autumn 2015.

4.5.3.3 Experiences with the use of a UiB developed system for digital exams

UiB has previously used a locally developed and administered exam system for digital exams.

This system was based on adjusting computers in the computer halls to “exam mode” to control access to the internet and software. This system was used a few times for the informatics class INF109, “Data programming for natural sciences”, the first time in autumn 2011. With this solution, students could work on the same interface during the exam as they did during instruction in the course of the semester. This is currently not an option with Inspera.

Nevertheless, this solution did have some clear weaknesses:

- Lack of tools for efficient evaluation of exam results.
- Manual management of submitted responses (at one point, a file with submitted responses temporarily “disappeared” en route from the exam hall to the examiner).
- Demands large resources from the IT department with regard to system development and maintenance over time.
- Difficult to implement on a large scale, as it requires the use of UiB equipment and does not utilise the students’ own equipment.

With the implementation of Inspera Assessment and the discontinuation of MiSide, the old exam solutions have been phased out. The advantage of using Inspera is that this system also supports evaluation of exam results and digital storage, as well as response sharing.

See the evaluation report after the digital exam for INF100 autumn 2013, where this system was used.

4.5.4 National resources and plans

The Centre for Excellence in Education and the Centre for Research Innovation and Coordination of Mathematics Teaching (MatRIC), based at UiA, have separate networks for digital assessment. Here the Faculty of Mathematics and Natural Sciences are represented by the Department of Mathematics. The working group was represented at a workshop on digital assessment for mathematics, organised by MatRIC, which took place at the University of Newcastle in April 2016. The main impression from this workshop was that the international focus on the use of digital tools (e.g. CAS-based software for digital corrections of math problems) leaned towards the formative rather than the summative assessments. This means that there was greater focus on practice and learning activities than on graded exams in terms of final marks.

UiB, UiA and UiO entered a partnership in 2014 for collaboration on the development of digital assessment methods based on Inspera. Coordinating resources aimed at the developer, and also the method and routines and the exchange of experiences, has enabled a faster pace for development and problem solving across institutional borders. Efforts are underway to ensure further implementation of digital assessment methods, as well as digital school exams.

Norgesuniversitetet (Norwegian Agency for Digital Learning in Higher Education) has appointed an expert group, led by UiB Professor Arild Raaheim. In spring 2016, this group will announce funds for the development of digital assessments, where the principles of constructive alignment will be key (Attachment 4).

4.6 Resource requirements, financial benefits and expenses

The implementation and introduction of digital assessment offers clear advantages for both administrative and academic staff, as well as for students (see 4.1). It is expected that the start-up phase will involve greater demands for resources for training, for the implementation of new digital tools, and for the development and improvement of digital routines. Resources will also be required for the acquisition of digital tools (program licences). Digitisation of assessments and the processes involved will, from an administrative standpoint, enable cost savings in the long run, as it is expected to free up resources that can be used for other purposes in the organisation. For academic staff, the proper implementation of the system will simplify work processes involved in assessments, and enable greater focus on student learning outcomes and improvement of instruction and assessment as a whole (cf. constructive alignment 3.1).

Altogether, it is expected that this system will in time lead to cost savings, both financially and in terms of individual resources, based on the implementation of digital assessments (e.g. evaluation report on digital exams at NTNU, 2015).

5 Conclusion and recommendations

The long-term goal for UiB, through the DigUiB-project on digital assessment, is that academic and administrative routines for exam procedures and assessments will become fully digitised. Students should be able to take their school exams digitally, submit their responses digitally and digitally receive their results from the examiners. Complaint and appeal procedures should also become fully digital.

By 2017, UiB also intends to offer technical and administrative solutions for digital assessments that are academically and educationally based, and in accordance with teaching methods and learning outcomes. Another goal is for all written exams to become digital by 2017.

Given the gap between the existing functionality of digital exams on the one hand, and the wishes and needs associated with digital exams as reported by the departments of the Faculty of Mathematics and Natural Sciences on the other hand, it is somewhat unrealistic to assume that the above-mentioned goals can be fully achieved for all maths and natural science subjects by 2017. For certain academic subjects, it may take some time before everything is in place.

Even if the technical challenges associated with the use of third-party software in Inspera are fully or partially solved in the long run, this does not mean that all of today's written school exams should be converted to a fully digital format.

The primary focus should remain on academic quality, and long-term efforts are required for the implementation of subject specific digital tools for the curricula before it can be considered expedient to use these for assessments. This is because students must learn to master the use of these tools before taking the exams, which in turn means that the tools must be utilised throughout the semester.

Thorough and long-term efforts on digitisation are required to ensure academically sound solutions, where the focus is on the coherent whole of the study programme and its subjects. Hasty and haphazard solutions that compromise academic quality, such as the exaggerated use of multiple-choice tasks, must be avoided.

Although full digitisation will be a long and arduous process, it is also clear that there are some short-term benefits that can be achieved almost immediately. For subjects that cannot currently use digitisation, it is possible to digitise exam responses after they are submitted, so that all further administration and grading can be done digitally, with the advantages that this entails. This should be possible quite soon, by having students submit their answers written in pen and paper, as before, and scanning these in the exam hall, either by the students themselves, or by exam proctors. Carbon paper will no longer be necessary, which simplify scanning. An evaluation of the necessary resources should be relatively easy to perform.

5.1 Short-term recommendations

- Evaluate the possibilities and resources needed to carry out partial digitisation, by scanning responses once exams are completed, so that the process will continue electronically through Inspera.
- In time, when Inspera enables the integration of third-party software, it may be advantageous to have a two-part exam, where answers in the first part are written with pen and paper and scanned (as proposed in the previous point), while the second part is answered digitally, possibly also with electronic grading. This should first be tested by a pilot study for specific subjects.
- There must be significant emphasis on improving user friendliness in Inspera.
- For subjects that have had digital exams, part of the evaluation must include an assessment of its function. Digital programs that will be used and integrated in instruction must be determined for each subject. These can then be used for digital exams later, when functionality is in place.
- Meeting places for the various departments should be established, where staff can discuss teaching and instruction, assessments and digital exams. E.g. one or more departments (depending on the type of tasks that may be relevant for digital exams) could invite academics who have already used exams in Inspera, in order to share experiences.
- Study programmes at UiB are to be revised by May 2017, and study programmes should be required to take constructive alignment into account in its revisions. Each study programme should also make sure to include digital competence as one of the learning outcomes of the completed programme.
- The expedient use of digital tools for teaching and assessment should be one of the primary criteria when awarding Excellent Teaching Practitioner status.

5.2 Long-term recommendations

- A (digital) school exam is possibly the least resource intensive type of exam, but this does not mean that it is the most effective way to test whether students have learned what we want them to learn. A long-term process is required if we are to utilise all the possibilities of digitisation in a manner that truly raises the level of quality. The Faculty's study programmes and subjects must be critically evaluated in order to determine the learning outcomes we want students to achieve. Assessment methods, instruction and learning activities must be viewed as a coherent whole (cf. constructive alignment). Have students acquired the (digital) skills needed for future employment and careers? Digital tools must be used throughout the course of study, so that students have the necessary digital competence by the time they are writing their master's thesis, as well as later in their careers. It is also important for students to acquire a deeper understanding of digitisation, which will enable them to evaluate the advantages and disadvantages of different types of software, and know when to use them.
- A renewal process of this type must be broadly anchored, and cannot simply be handed over to dedicated teachers in specific subjects. Contributing to this process must be an attractive prospect. It is important to start up one or more pilot studies to lead the way. The Working Group believes that the bioCEED Centre of Excellence should play an important role in such a process. There must also be some incentives to make this work, e.g. emphasis on awarding Excellent Teaching Practitioner status.
- At a national level, there are clear similarities between efforts towards digitisation at all higher education institutions. Many of these institutions are now moving forward from the pilot study phase, where the implementation of digital assessment tools has been the primary focus. This offers a greater opportunity for national cooperation on digital assessments, since many of the challenges are the same. The Working Group believes that greater cooperation between institutions on the same challenges would play an important role in ensuring the best possible digitisation of the university and university college sector. The National Faculty Meeting for Mathematics, Science and Technology should also enable the exchange of knowledge and experiences with digital exams in these subjects.

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Figures

Figure 1 Constructive alignment

http://www.ucdoer.ie/index.php?title=File:Aligned-curriculum-model.gif

Tables

Table 1 SOLO Taxonomy

https://primus.systime.dk/index.php?id=231

7 Attachments

Attachment 1: Assessment methods for exams in the exam revolution (Raaheim, 2016)

Attachment 2: Learning outcomes and assessment criteria BIO100

Attachment 3: Requested programs for digital exams by the departments

Attachment 4: Call for proposals from Norgesuniversitetet (the Norwegian Agency for Digital Learning in Higher Education)

Type of exam	**Number in Raaheim (2015)**	**Name**	**Assessment method**	**Compatible with the current system?**
Written	1	With own notes/cheat sheets	School exam	Yes
Written	2	With opportunity for obtaining information/discussion	School exam	Not directly. Opportunity for 2 tasks, with/without
Written	3	Open to all types of sources	School exam	Yes, exam without SEB in exam hall
Written	4	Take away exam / home exam	Home exam	Yes, exam without SEB
Written	5	Individualised exam	School exam	Not directly. Requires high level of
Written	6	Objective test / multiple-choice	School exam	Yes, but cumbersome with many tasks
Written	7	Reverse objective test	School exam	Yes, as long answer task
Written	8	The student as an examiner	School exam	Yes, as long answer task
Written	9	Station exam	Practical exam	Grading and marking through IA
Written	10	Professional article	School- and/or home exam	Yes, as final exam (IA) and during studies with peer-review (MittUiB)
Oral	11	Time for preparation	Oral exam	Grading and marking through IA
Oral	12	Preparation of a complaint/appeal	Oral exam	Grading and marking through IA
Oral	13	Poster presentation	Oral + home exam	Submit through IA, graded through IA
Oral	14	Practical oral exam	Practical - and oral exam	Grading and marking through IA
Oral	15	Disputation	Oral exam	Grading and marking through IA
Oral	16	Lecture	Oral exam	Submit through IA, marked i IA
Oral	17	Interview (popular science)	Oral exam	Grading and marking through IA
Other	18	Participation in a scientific conference	Practical exam	Grading and marking through IA
Other	19	Portfolio assessment	School- and/or home exam	Work with IA, 1st level structure, Portfolio
Other	20	Virtual conference	Home exam	Yes, through MittUIB
Other	21	Practical assignment outside the university	Practical – and or home exam	Grading and marking through IA
Other	22	Commissioned work	Practical – and or home exam	Grading and marking through IA
Other	23	Log	School- and/or home exam	Yes, through MittUIB
Other	24	Interviewing a professional	Home exam	Yes, exam without SEB
Other	25	Field placement	Home exam	Yes, exam without SEB
Other	26	Project presentation	Home exam	Yes, exam without SEB
Other	27	Assessment of fellow students	School- and/or home exam	Yes, through MittUIB
Other	28	Chronicle	Home exam	Grading and marking through IA
Other	29	Review of the literature	School- and/or home exam	Yes, exam with or without SEB
Other	30	Course review	School- and/or home exam	Yes, exam with or without SEB
Other	31	Planning a teaching session	School- and/or home exam	Yes, exam with or without SEB
Other	32	Blog post	Home exam	Yes, through Wordpress@UiB
Other	33	Facebook (SOME) group	Home exam	Yes, through MittUIB
Other	34	Film	Home exam	Yes, through IA or MittUIB
Other	35	Team-based learning (TBL) activity	School and/or home exam	Yes, through IA or MittUIB
Other	36	Organising a professional activity	Home exam	Grading and marking through IA
Other	37	Analysis of an assessment method	Home exam	Yes, exam with or without SEB
Other	38	The student as a teacher	Practical and/or home exam	Grading and marking through IA
Other	39	The patient as an examiner	Practical exam	Grading and marking through IA
Other	40	External exam evaluation/grading	All types	Grading and marking through IA

BIO100 UPDATED LEARNING OUTCOMES FROM 2016H

LEARNING OUTCOME	Partial exam			
	1	2	3	4
Knowledge				
1. Understand how biology is organised hierarchically and systematically.	X			X
2. Have knowledge of the history and core logic of the theory of evolution, and of Darwin and other key figures.	X		X	X
3. Understand how evolution occurs on an individual and population level, and that it has a molecular basis.	X		X	X
4. Have knowledge of central concepts, definitions and theories regarding ecology, behaviour, learning, life history, population dynamics, genetics and	X	X	X	X
5. Understand how selective pressure occurs in ecological interactions, and in competition between individuals and species.			X	X
6. Be aware of the central elements of the origins of life and development on Earth, including human evolution.				X
Skills				
7. Solve simple equations and perform simple calculations in the field of population dynamics and genetics, using spreadsheets, etc.	X	X		X
8. Be able to read and explain graphs with research results.		X	X	X
9. Be able to perform a simple search for relevant research literature, and utilise correct source references.			X	
General competence				
10. Use precise biological terminology to describe and discuss biological phenomena.	X	X	X	X
11. Be able to see parallels and make connections between various biological disciplines, unifying these within the theory of evolution.			X	X
12. Recognise and discuss evolutionary issues through descriptions of biological systems.			X	X

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BIO100 ASSESSMENT CRITERIA PARTIAL EXAM 1-4 FROM 2016H

Partial exam 1 (max. 20 points)

Assessment criteria	Learning goals	Satisfies expectations	Exceeds expectations
Demonstrate knowledge from Campbell, chapters 1, 5, 14.1-2 and 23.	1, 2, 3, 4	8	12
Give precise definitions of central academic concepts.	10	3	5
Solve simple genetic equations.	7	2	3
Total		**1**	**20**

Partial exam 2 (max. 20 points)

Assessment criteria	Learning goals	Satisfies expectations	Exceeds expectations
Show a deeper understanding of the course literature on population dynamics.	4	3	5
Perform calculations using a spreadsheet.	7	3	5
Create, explain and interpret graphs from collected and simulated data.	8	3	5
Use precise academic terminology in the report.	10	3	5
Total		**1**	**20**

Partial exam 3 (max. 20 points)

Assessment criteria	Learning goals	Satisfies expectations	Exceeds expectations
Demonstrate clear and logical thoughts on evolution by discussing assessments and evolutionary issues regarding the characteristics of organisms.	12	5	8
Have knowledge of central concepts regarding selection, adaptation and evolution.	2, 3, 4, 5	2	4
Use precise academic terminology and make connections between concepts.	10, 11	2	4
Find and use relevant research literature with correct source references.	8, 9	2	4
Total		**1**	**20**

Partial exam 4 (max. 40 points)

Assessment criteria	Learning goals	Satisfies expectations	Exceeds expectations
Demonstrate knowledge and skills from the entire list of course literature (contents).	1-8	1 0	15
Provide and use precise definitions of central terminology (precision, especially for short answer questions).	10	6	10
Recognise and discuss evolutionary issues (logic, especially for long answer questions).	12	6	10
Make connections between parts of the course literature (overview, especially for long answer questions).	11	3	5
Total		**2**	**40**

Attachment 1 Desired functions and programs for digital exams

Department	Desired functions	Desired programs
Department of Biology	It must be possible to create drawings for the exam. Inspera Assessment's drawing tools are not good enough to meet our needs, and we are worried that the level of detail in a digital solution is inadequate, or requires extra effort by the students in order to function satisfactorily. We therefore wish to continue using an attachment sheet.	Several subjects wish to use R during digital exams for writing codes and running analyses. We are interested in using Matlab and Python later on. It must also be possible to write formulas in the exam responses, and to compile codes.
Department of Geoscience	Students must be able to make illustrations, in addition to writing text answers. So far we have solved this problem by having students illustrate on attachment sheets, but this is not an optimal solution in the long run. In order for more of our exams to become 100% digital, we need an advanced drawing program in Inspera. At the moment, we have no specific suggestions for such a program. Several of the course teachers have pointed out that it will be necessary to use pen and paper for certain subjects, considering the unique quality of the discipline.	We also require a program that enables the student to do mathematical calculations and write equations with mathematical symbols. We suggest a stylus-based system. MatLab is used for instruction, but certain course teachers have expressed that they do not wish to have students use this on the exam. We would also like the opportunity to use Excel on the digital exam.
Department of Physics and Technology	All of our subjects with written exams have exam tasks that must be answered using mathematical calculations and derivations. Drawings and diagrams are also included in most of the exam responses. In order for digital exams to be carried out for these subjects, it must be possible to write answers that are primarily composed of mathematical expressions in a manner that is just as efficient as handwriting on paper. The main requirements for digital tools include the opportunity to write equations and to create drawings in a user-friendly and efficient manner. Drawings done on a drawing pad/tablet using current technology would not have the same quality as the drawings done on paper, and they appear to be more time-consuming.	

Department of Geophysics	Students must be able to write formulas and equations, show calculations and derivations, and make drawings in a simple and efficient manner. It must also be possible to insert symbols and Greek letters in their text answers. In our opinion, the same or equivalent software should also be used for instruction. Tools must be adequate and user-friendly before digital exams can be implemented for many of the subjects, and digital exams are not necessary expedient for all subjects. In order for digital exams to be carried out for our subjects, it must be possible to write responses that largely consist of mathematical expressions, and drawings that are just as efficient as handwriting on paper.	MATLAB is used for instruction in certain subjects, and may be appropriate for use during exams. This could also possibly apply to Python and LaTeX.
Department of Molecular Biology	It must be possible to draw in the program and insert scans.	MOL221 and MOL222: Teachers have used Socrative, which is an online poll with question and answer interactions, including brief written answers that can be shown directly. Socrative has some functional limitations compared with programs such as PollEverywhere, which has a better functionality (e.g. can be inserted directly into a PowerPoint presentation), or Kahoot. MOL204: Jalview (a Java-based program for multiple sequence alignment). Jmol (a Java-based program for simple visualisation and analysis of molecular structures), or preferably PyMol (instead of Jmol). In this course we use many of the programs that are solely web-based (e.g. Blast@ncbi, clustal-omega@EBI etc.) and several of these could be useful for the exam, such as programs based on the statistical system “R”.

Department of Mathematics, including teacher training	A digital exam in mathematics subjects (with the current format of exam questions) would require the opportunity to write texts and formulas interchangeably in the same document.	MATLAB, R, Geogebra, LaTeX, Maple, Maple TA. For exams, there is a strong need for access to Word (or something better) with a formula editor, i.e. the opportunity to write formulas in a regular text program, since students do not begin using LaTeX before later in their studies. This is essential if our exams are to become digital. A few teachers have also expressed the wish for the use of a tablet, where formulas can be written in freehand (with a “pen” on the tablet, like a drawing) during the exam. This means that each student would be loaned a tablet during the exam, which may be expensive, but it is something we would like to see, and it would be feasible for exams with few participants.
Department of Chemistry	It must be possible to write exam responses that primarily consist of chemical formulas and mathematical equations, in a manner that is just as efficient for the students as writing these by hand. Writing mathematical formulas, writing chemical reaction equations and formulas. A formula editor, a tool for showing intermediate calculations up to the final answer. Create molecular structures and draw reaction mechanisms. Opportunity for students to give a few (graphic) responses on a touchscreen placed flat (touchad with electronic pen) to avoid using difficult formalised digital formats/programs. Students would then draw figures and write mathematical equations or stoichiometric calculations in their "own hand", which would be simple, fair and also reveal the level of student knowledge.	Chemdraw, Excel, Calc, Word/ LibreOffice/LaTeX, Linux/OS X, Marvin JS from Chem-Axon or ChemDoodle, JChemPaint.

Department of Informatics	Opportunities to write code and compile it. Write mathematical formulas and symbols. Access to logical notations that are easy to use.	Python, AMPL/CPLEX, CPLEX, write formulas, compile codes, draw ER diagrams, run Java, JDBC, XML, MySQL, PHP, wireshark (without captured packets). Naturally also the flexibility needed for integration of new programs as needed.
For more detailed information, see case 15/10848 and 15/5831		

Universities and university colleges, according to the list

Your ref.: Our ref.: 2015/1059 VAM000/300 Date: 12.05.2015

Project grant announcement for 2016 by Norgesuniversitetet

Norgesuniversitetet (the Norwegian Agency for Digital Learning in Higher Education) hereby announces project funds intended to stimulate the development and application of technology for learning and flexible study programmes for higher education, and to promote cooperation between institutions of higher education and employers through the use of learning technology. The Ministry of Education and Research has provided guidelines for the use of these funds (see Attachment 1), and in accordance with these guidelines, Norgesuniversitetet announces project funds for 2016 in two areas of priority:

- Active learning
- Digital learning methods for working life

All Norwegian accredited universities and university colleges can apply, and we ask that these institutions forward this announcement to their respective departments.

A complete announcement can be found on our website: http://norgesuniversitetet.no/prosjekter.

Deadline for applications is 15 October 2015.

Applications must be approved by the central management of the applying institution. Should an institution wish to send several applications, these will be ranked. Applications must contain a description of how the project will be used in the learning institution's strategic work on educational quality, including the digitisation of the study programmes, as well as cooperation with employers, and it is essential for management to approve and rank these applications based on these elements. An accompanying letter with this approval must be sent from the dean/director's office before the deadline to: post@norgesuniversitetet.no.

Norgesuniversitetet will hold its annual fall conference on 15 and 16 September in Tromsø. The conference will include presentations from projects funded by Norgesuniversitetet, with emphasis on examples for potential applicants for project grants. There will also be a separate applicant seminar.

Individual guidance for applicants can also be provided upon request, either online, by phone, or in person.

Norgesuniversitetet
NO-9037 Tromsø, Tel: +47 77 64 40 00, E-mail: post@norgesuniversitetet.no, http://norgsuniversitetet.no
Officer manager Vigdis Amundsen, Tel: +47 77 64 59 57, Fax: +47 77 64 59 60,
E-mail: vigdis.amundsen@norgesuniversitetet.no

During the past several years, Norgesuniversitetet has allocated approximately NOK 12.5 million annually for project grants. However, the total amount allocated for project grants in 2016 will not be determined until the national budget for 2016 is presented and determined this fall. Funding is therefore subject to budget decisions by the Norwegian Parliament.

Best regards,

Eva Gjerdrum
Director

Vigdis Amundsen
Administrative Manager

This document has been electronically approved and does not require a signature.

Attachment:
Guidelines for the use of Norgesuniversitetet project funds
2016(1)
Overarching project guidelines

Copy:
Norgesuniversitetet's contacts, according to the list
Office of the Auditor General of Norway