IO3 Developing Didactics

The InRoad project aims to improve on the didactics currently used to teach road design software. Novapoint is the specific road design software used in this project; thus, it will be referred to during the remainder of this report, but the results are not specific to Novapoint alone. Three groups of "actors" are considered within the didactical approach: students, instructors, and affiliated external "experts."

1. Review of existing didactics

The four universities participating in the project use slightly differing teaching methods to teach Novapoint (or similar, relevant software), as described below in Table 1. There is also further information on the current state of practice at each university in *Intellectual Output 1: Clarification on knowledge and practices*.

University	Description of existing teaching methods
AAU	Students are introduced to Novapoint in their third year, where they work on designing a bypass road in a rural area in their semester project. The introduction is made by an external expert, usually a civil engineer from a consulting firm. There are allocated two sessions of 4 hours. Each session consists of a presentation and some hands-on exercises, but it is through the semester project that the students get more familiar with Novapoint. The expert is also, to some extent, available for the students to contact during the project work. The project is evaluated through an oral group exam at the end of the semester.
JU	Students are introduced to Novapoint in Year 2 as they learn about the ground model and subsurfaces and use the landscape module. In Year 3, the students learn theory about road design and afterward carry out exercises to learn different parts of the Novapoint program, first by having a teacher-led review where the students follow what the teacher is doing. After that, they get to work on their own project with the same parts they did together with the teacher. The time allocation is 2+2 hours per week over 5 weeks. The projects are submitted and assessed by the instructor. Instructors at the university carry out both training in theory and software as well as support.
NTNU	The Novapoint component of the road design course (where students are first introduced to the software – in their third year) is a project-based assignment. An external "expert" (i.e., a Trimble employee) is hired to teach the students the software through an interactive, in-person tutorial. Students then use this knowledge to work through a road design task. Additional external "experts" (i.e., road design engineers from local consultant firms) are hired to provide in-person support to students both in using the software and also engaging in discussions about road design best practices. The students also have access to a written software tutorial (not specific to the project itself, but instead to the software modules). The project is completed over 4 weeks with ca. 6 hours per week of dedicated time in the computer lab with guidance from the external "experts" and student assistants. The final deliverable is a completed road project presented orally to the course instructor (students sit in front of the computer and present their road project, addressing specific aspects of the assignment and showing their proficiency with using the software).
OU	During the road design exercise part of the Road Design and Construction course, the teacher introduces used tools (Novapoint and AutoCAD) and the design work. The teacher also supports students during their independent work (72 h). One

	expected result is a project report in a learning diary format where students explain used design principles, justifications, and effects. Delivered materials also include, e.g., longitudinal section image, cross-section image, and layout (or project map) map as a pdf file and measurement data in Landxml format. The course is implemented in a 6-week course period.

2. Main considerations for developed didactics

The project participants' past experiences were used to determine the initial aims and intents when developing the InRoad didactics. Similar to the current teaching methods, there was a strong desire to maintain the project-based and student-centered learning approaches within a Novapoint task. Students should learn how to use Novapoint through hands-on learning in the context of a "real-life" project. For example, this is currently highlighted in several of the learning objectives for the road design course at NTNU: *Students will be able to apply theoretical road design concepts within the context of an integrated road design problem,* and *Students will be able to understand how computer tools such as NovaPoint facilitate road design and be able to perform basic functions within the Novapoint program to produce alignments and a road model*. Thus, based on previous experience, student-centered learning was a primary didactically focus.

Additionally, there were two main concerns related to one another. First, course instructors may have a degree of previous experience with Novapoint (e.g., from previous work experience). Still, they cannot keep their Novapoint expertise updated in a university setting, particularly given the speed at which the software changes and develops. Thus, there is currently a heavy reliance on external expertise to execute course modules/tasks associated with Novapoint successfully. This is then related to the second concern, a general disconnect between the theory associated with road design and the technical use of digital tools. From an academic perspective, theory related to physics and geometry is an integral part of learning and understanding within road design. Instructors have the competence to teach this theory to students throughout a course. In an ideal situation, this theoretical component would also be carried through the introduction and training of Novapoint. When the course instructors need to rely on outside instruction to teach the students how to use Novapoint, it has often been experienced that there is a lack of integration with the theory and instead a large focus on the technical use of the software. For example, much time is spent understanding the theory behind the required length of clothoid transition curves. Still, in the Novapoint tutorial, this is often skipped over (because it is "just a detail that can be added in later") to focus on other aspects of using the software instead. This happens because there is a disconnect between the teaching of the theory and the teaching of the software. While this can be addressed to some degree through communication, it is difficult to fully address the issue without having the course instructor as a more integral part of the Novapoint instruction, which is then also difficult given the instructor's lack of up-to-date expertise with the software – a circular problem that it is a challenge to solve given time constraints and other responsibilities. Regardless, the project aimed to develop a didactical approach that addressed these existing concerns.

3. Description of didactics within InRoad

As previously mentioned, student-centered, active learning is a primary focus of the InRoad project. The project utilized an iterative process to develop, refine, and improve the didactics throughout the four workshops. Several different methods of learning are used in our approach. For each, a short description is given, followed by a discussion of how the method was utilized in the project.

3.1 Lecture Method

This is a traditional approach where the teacher presents information to the students through a structured presentation. Typically, lectures involve the instructor explaining concepts, theories, and principles while students take notes and listen actively. While teaching Novapoint, the instructor explains how the software works and the processes used. This is primarily done by working directly in Novapoint and sharing the screen with the students. At times, a PowerPoint presentation is shared to identify key pieces of information related to software use.

In the case of the InRoad project, we engaged Novapoint experts from the software developer (Trimble) to provide what we called "Novapoint Advanced" sessions. These sessions utilized the above-described lecture method to teach the students the skills needed to use the software. The Novapoint instructor was located remotely for all four workshops, and the session was conducted via Zoom or Teams. The ability to engage the software developer provided the students with high-quality, up-to-date knowledge about the use of Novapoint. Still, it relied on having personal connections at Trimble who were willing to provide these services within the project voluntarily.

During these lecture sessions, the students were asked to watch and take notes on the material presented instead of following along on their own computers. The reason for this was to encourage students to absorb the processes and connections between tasks and not just follow, potentially mindlessly, through a step-by-step procedure.

In the first workshop (Oulu), the lectures were only shown on a screen at the front of the room, which functioned well enough, particularly when the room used for the workshop was small. When the room size became larger in subsequent workshops, it was difficult to see the menus and buttons used within Novapoint from a distance. Thus, after feedback from students, we shared the link to the virtual meeting with the students, so they could also use their individual computers to watch the screen. This was found to be a helpful adjustment. Additionally, we explored the potential of recording the lectures for the students to use later during their design sessions. For the second workshop (Jonkoping), the videos were stored on the common drive used for the workshop, meaning the students each have (easy) access to them. Students utilized these videos, but it was observed that there was less interaction between students. Previously, when a student was unsure of how to complete a task within the model, they discussed amongst their group members to find a solution. But with access to the videos, students would instead individually utilize the video to solve their issues. Thus, in the third workshop (Aalborg), the lecture videos were placed on one computer workstation. The intention here was that students could watch collectively (and discuss), or one student could watch and then return to their group and disseminate what they learned. Yet, it was found that when the students were forced to "travel" to a workspace to watch the videos, they did not watch the videos and again returned to discussions and interactions with their group members. Thus, for the fourth workshop (Trondheim), the students were not given access to the video lectures.

3.2 Project-Based Learning (PBL)

PBL involves students working on extended projects that require them to apply their knowledge and skills to solve complex problems or create a tangible product. It encourages collaboration, research, creativity, and self-directed learning with a focus on the final output. In the case of the InRoad project, the students were presented with a real-life road project (located in Sweden) and used existing base maps and design standards to design and model a road project (including cross-roads, ramps, and other design aspects). During "Project Work" sessions throughout the week, students utilized the knowledge and skills gained in the "Novapoint Advanced" sessions to complete the project tasks. Given the complex nature of the project, the student groups were required to discuss workflow and delegation of tasks. To help address issues with the software, students had access to a "local expert" (i.e., a member of the InRoad team). Additionally, starting with workshop 2, dedicated time for discussion of project status and issues was included in the time plan. These sessions occurred in plenum and gave groups a chance to learn from each other.

3.3 Cooperative Learning

In cooperative learning, students work in small groups to achieve common goals. Each member of the group has a specific role or task, and they collaborate to complete assignments or projects. Cooperative learning promotes teamwork, communication skills, and social interaction. The Novapoint task within the InRoad project was designed to be completed by cooperative groups of 3 to 4 members. One aim of the InRoad project was to provide students with experience within a global/international work environment (tied to *Intellectual Output 4 The Work Environment in a Global Context*). Thus, the groups were multinational, with one student from each country in each group. International collaboration considerations are seen related to cooperative learning within the groups.

The common language of the groups was English. While most students were comfortable speaking in English conversationally, initially, there was hesitation regarding speaking about technical topics. This hesitation lessened over time, and by the end of the workshops was not found to be a problem. The design standards and guidelines used within the project were written in Swedish, but students were provided with an English translation (and each group included a Swedish-speaking student). It was also determined that it was best for students to set up the software to have the menus and toolbars presented in English. This allowed for easier assistance and cooperation using the program.

Experience and skills levels with the Novapoint software varied between participants, and several strategies were considered in assigning groups – from random assignment (workshops 1 and 2), to groupings based on even overall distribution of competence (workshop 3), to groupings based on similar competence (workshop 4). There was no clear conclusion on the best way to arrange groups. For example, when groupings were based on an even distribution of competence, those with the highest level of competence felt like they had the responsibility for teaching the other group members, which was frustrating to them. Yet, when distributions were based on similar competencies, the groups with a lower overall level of competence were less successful at completing the assignment tasks than those groups with higher competence levels.

In addition to cooperation within groups, collaboration between groups also developed. This was seen as naturally occurring within workshop 3 (Aalborg), where during breaks, students from different groups gathered to discuss their approaches to various problems within the task. Furthermore, when working in their groups, students also began to visit other groups to ask for help or insight with various tasks as needed.

3.4 Experiential Learning

This approach emphasizes learning through direct experience and reflection. It often involves hands-on activities, experiments, field trips, or simulations that allow students to actively engage with the subject matter. Experiential learning enhances practical skills, critical thinking, and application of knowledge. At its core, the Novapoint task is experiential, giving students hands-on experience with the software. The organization of the curriculum, where students are first introduced to concepts through lectures and then asked to complete tasks, gives students the opportunity to apply learned concepts within their group work.

An additional component to the curriculum, a module on Integrated Concurrent Engineering, also heavily utilized experiential learning. Integrated Concurrent Engineering (ICE) is a structured approach that emphasizes interdisciplinary teamwork in project settings. A key aspect of this approach is the implementation of well-organized work sessions scheduled at regular intervals throughout the project duration. During these sessions, design tasks are actively performed, and immediate decisions are made in real time. ICE was introduced to the students starting with the second workshop (Jonkoping) and continued through the remaining workshops (Aalborg and Trondheim). The ICE component of the curriculum consisted of a short lecture on the concept, followed by a hands-on activity that involved role-playing to simulate an ICE session connected to the Novapoint project. This activity allowed students to experience the key components of the ICE process. The activity was modeled after an existing activity within a continuing education master-levels course, yet after the first execution of it within the InRoad project, it was evident that adjustments would need to be made based on the experience level of the students. When the ICE simulation activity was executed originally within the continuing education course, the students had existing work experience they could draw from, particularly within role-playing. As the students within the InRoad project had limited work experience, they found it challenging to understand the different roles they were to play in the activity (i.e., asset owner, consultant engineering, public transport representative…). Thus, in the second iteration of the activity (third workshop, Aalborg), students were provided with further resources (i.e., examples of project documentation written by various stakeholders, providing different points of view) to understand their roles better. In the third iteration, “break-out” sessions were added to the agenda to allow stakeholders to gather at various points within the ICE simulation to discuss their strategies and perspectives within the activities. Both these changes allowed students to understand further and then better act out their roles within the simulation, resulting in better execution of the task.

4. Evaluation of the didactics

While there is a more detailed discussion of the InRoad project evaluations in *Intellectual Output 5 Developing Assessment Methods*, several of the evaluation questions are particularly relevant to the discussion of didactics. Table 1 shows the results of the questions for the evaluation of the teaching methods, where students answered on a Likert scale of 1-5, where 1 was strongly disagree and 5 was strongly agree. Most notable to the discussion on didactics are the second and third statements below. In response to the statement, *I felt encouraged to actively engage within the workshop*, the average response over the four workshops was 4,26, indicating that students agreed or strongly agreed with the statement. Given that the task was project-based and greatly focused on experiential learning, this result is in line with the intended outcome of the InRoad project. Additionally, in response to the statement, *There was a good balance between lectures and practical tasks*, the average response was 3,90, indicating that the lectures complement the practical Novapoint sessions well. The final statement within the table, *There was enough time to fulfill the tasks*, has the lowest overall results here at 2,78. This is not unexpected as the task given to the students was larger than the time allotted to do them. Verbally, the project team assured the students that it was not necessary to complete the entire project in order to achieve the learning outcomes (e.g., it was not necessary to design all four ramps from the motorway to the secondary roadway, completing one or two ramps is adequate). Another alternative in future

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iterations would be to make slight adjustments to the task text, to further align student expectations.

Table 1: Evaluation of teaching methods

Workshop	Oulu (N=20)	Jönköping (N=15)	Aalborg (N=17)	NTNU (N=18)	Average (N=70)
The tasks were clear and well formulated	3,50	4,20	3,59	3,80	3,85
I felt encouraged to actively engage within the workshop	4,40	4,20	4,12	4,33	4,26
There was a good balance between lectures and practical tasks	3,35	4,13	3,71	4,40	3,90
The educators presented workshop material in a clear manner that facilitated understanding	3,20	3,80	3,76	3,93	3,67
The educators were well prepared, and used workshop time efficiently	3,30	3,67	3,59	4,33	3,72
There was enough time to fulfill the tasks	2,80	2,93	2,53	2,87	2,78

Students were also asked to consider the InRoad method in comparison to the ways they previously learned about Novapoint, as seen in Table 2. Again, students answered on a Likert scale of 1-5, where 1 was strongly disagree and 5 was strongly agree. The results indicate the students agree that the InRoads method of learning was an improvement on traditional learning methods (for learning software). Most notably, students highly agreed that *The workshop setup allowed [them] to better collaborate with the group/other students*.

Table 2: Comparison of the InRoad workshop to the way students previously have learned Novapoint

Workshop	Oulu (N=20)	Jönköping (N=15)	Aalborg (N=17)	NTNU (N=18)	Average (N=70)
The workshop setup allowed me to better collaborate with the group/other students	4,15	4,13	4,12	4,53	4,23
The InRoad workshop setup was a more effective way to learn Novapoint	3,60	3,87	3,53	4,27	3,82
The way to learn using Novapoint at InRoad workshop was more engaging compared with my previous experience	3,70	3,80	3,76	4,33	3,90
Compared to my previous learning experience, I expect to retain more knowledge from the participation in the workshop	3,75	3,60	3,88	3,93	3,79

Several evaluations were asked specific to the ICE module project, as seen in Figure 3 below. As with the previous results, students answered on a Likert scale of 1-5, where 1 was strongly disagree and 5 was strongly agree. Note that the ICE session was only implemented in the final three workshops. The results indicate that the ICE session became clearer and more understandable as the workshops progressed. This is likely due to the iterative process used to develop and improve the module based on student feedback. Additionally, students indicated that they understood the concept of ICE and could work in an ICE environment. Overall, the results of the evaluation show that students learned from and enjoyed the ICE module within the InRoad project.

Table 3: Evaluation of the ICE module

Workshop	Jönköping (N=15)	Aalborg (N=17)	NTNU (N=18)	Average (N=50)
The ICE session was clear and understandable	3,07	3,35	3,80	3,40
I have an understanding of the concept and purpose of Integrated Concurrent Engineering	3,60	3,94	3,94	3,83
I can work within an ICE environment.	4,00	3,88	4,19	4,02
I can plan, execute, and evaluate a simple ICE session	3,80	3,71	4,06	3,86
The ICE session was useful for my future education	3,67	3,06	3,35	3,36
The ICE session was useful for my future career	3,80	3,35	3,53	3,56
The ICE session strengthened my knowledge and skills regarding interdisciplinary collaboration	3,53	3,41	3,47	3,47

5. Final summary and conclusions

The didactical methods used within the InRoad workshops, notably cooperative learning in an international setting, were found to be successful in engaging students and increasing student learning. The learning methods and associated curriculum have a basis within the traditional learning methods used to teach software, i.e., project-based, experiential learning, for which the project consortium universities have strong experience. This prior experience likely contributed to the effective results of the project. Regardless, the ability to execute the didactical methods and curriculum within the workshops to a diverse group of students from several universities highlights the transferability potential.

At the same time, the didactical methods and curriculum within the workshops did not fully address the initial concerns with teaching such software as Novapoint. With regards to the lack of software expertise by the university instructors, the workshop structure utilized both external and internal support regarding the software. Both sources of support have challenges; external support often requires economic resources (or willingness for external partners to contribute their time without payment), and internal support requires internal expertise, which is the problem itself.

Future development of the InRoad method could address these challenges by considering options such as recorded video lectures and digital supervision. The challenge of using recorded video lectures and their potential to decrease student cooperation in solving problems was identified in this research. Thus, it is particularly important to consider how video lectures are utilized to ensure continued student collaboration. Additionally, if there is no internal competence in Novapoint, it could be possible further to utilize external competence in activities beyond the lectures. This could be done virtually, where students connect via a break-out room in Teams or Zoom (or the like) and are able to share their screen to get assistance. This, though, likely requires economic resources or strong cooperation agreements.