Ide3a Project 2020 - 2023

Final Report

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Executive Summary

This document summarizes the evaluation conducted on the e-learning side of the ide3a project across the years 2020-2023. As part of the DAAD program "International Mobility and Digital Cooperation" (IMKD), financed by the Federal Ministry of Education and Research (BMBF), the ide3a project pursued all four program goals, with the teaching activities focusing on "Building methodological knowledge and digital competencies through the development of digital teaching and learning scenarios". Using internally created pre- and post-course surveys, the effectiveness of the courses conducted within the ide3a project were evaluated. Overall, across the six evaluated semesters, the ide3a project could significantly increase skill levels of participating students in seven out of nine evaluated digital competencies (pg. 9-10). Results within each course varied slightly and are outlined in the respective semester summaries in chapter 3 of this report, as well as in the ILO overview on pg.9. The courses were especially successful in conveying methodological knowledge, as students showed already relatively high levels of confidence in their digital competencies before taking ide3a courses.

The challenge-based learning formats trialed in the ide3a project, in both virtual and blended format were overall successful. Not only were they able to promote digital competences but also yielded positive feedback on the format and organization themselves. They also point to the importance of incorporating social activities and moments of interaction and engagement, especially in virtual teaching settings. Further, skill-focused teaching activities, such as workshops, profit from being held entirely in presence, which should be considered in the design of blended formats. With regard to designing challenge-based learning formats, the ide3a project as proven the importance of constructive alignment, with positive feedback and learnings continuously increasing, the more the exam formats, ILOs would guide the schedule and outline of the course. In more traditional 'front-based' teaching formats, it has additionally been successful to experiment with shorter lecture durations and additional discussion and feedback formats, suggesting that students are open and willing to try out new didactic formats when it comes to knowledge transfer. To further experiment with the most effective levels of digital communication and education, future courses could expand on the use of asynchronous teaching material and synchronous (possibly in-presence) discussion and workshop formats.

Chapter 1: Introduction

Over the course of three years (2020 – 2023), the [i]nternational alliance for [d]igital [e]-learning, [e]-mobility and [e]-research in [a]cademia (ide3a) project has established and tested various teaching concepts around the topic of 'Critical Infrastructure & Digitalisation'. The goal was to support international short-term mobility and strengthen digital competences in blended learning settings. The COVID-19 pandemic on the one hand aided the acceptance of utilizing new technology in digital education settings, and on the other hand made physical short-term mobility more difficult to implement. As part of the DAAD program "International Mobility and Digital Cooperation" (IMKD), financed by the Federal Ministry of Education and Research (BMBF), the ide3a project pursued all four program goals, with the teaching activities focusing on "Building methodological knowledge and digital competencies through the development of digital teaching and learning scenarios". The pursuit and outcome of this goal are outlined and presented in this report.

Ide3a was developed as a collaborative effort by a multidisciplinary and international consortium of five European partner universities, led by the Technical University of Berlin (TUB) and including the Norwegian University of Science and Technology (NTNU), Politecnico di Milano (PoliMi), Cracow University of Technology (CUT) and Dublin City University (DCU). Throughout all five active semesters of the project partners from all universities contributed teaching content and advertised the program to potentially interested students. The teaching activities of ide3a differed between the winter and summer semesters. As also illustrated in Figure 1, during the winter semester ide3a offered initially 3, later 2 block courses in the form of 'winter schools', which made use of challenge-based learning formats and challenged participants to develop solutions during a three-day hackathon event following previous lectures and workshops.
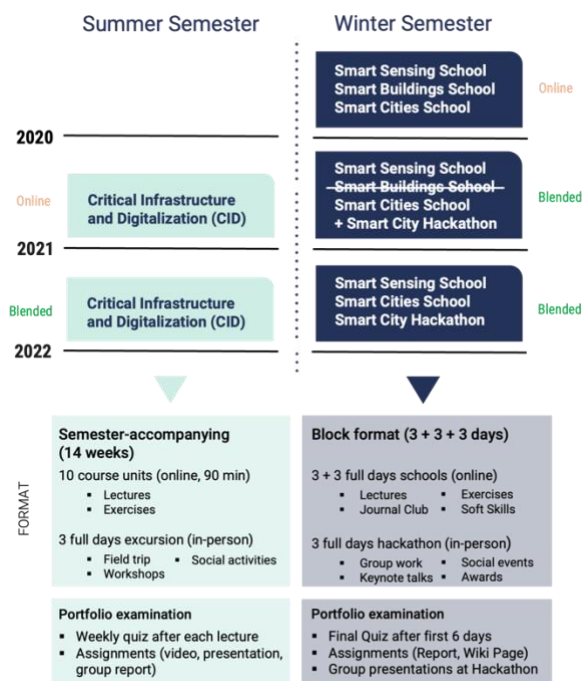

Figure 1. Teaching Formats Overview

During the summer semester, a semester-long course was offered, which was slightly more oriented in 'traditional', front-based teaching, taking the form of a weekly lecture series, coupled with workshops. Here we experimented more with the assessment formats and lecture length. With the intention to activate students in the entirely digital setting lectures were kept to max. 45min and an equal amount of time was spent on discussion. Students first discussed in smaller groups amongst themselves and then had the opportunity to address questions to the speaker of the week. The assessment consisted of summative quizzes, an individual reflection video assignment and a group report. We also experimented with additional group presentations in the first year, but in accordance with feedback from the students limited the portfolio to three components.

For each course, students were asked to participate in surveys before and after to measure the effectiveness of ide3a courses in conveying the intended learning outcomes (ILOs), but also to continuously gather feedback on the chosen formats. This feedback was invaluable to adapt the respectively next iteration of the courses. Chapter 3 of this report collect and present all feedback that was collected across all semester and courses. Overall, the feedback was quite positive from the first iterations, so that the general format of 'block courses' for the winter semester and 'semester accompanying' for the summer semester was kept by. The very first iteration of the winter schools, offered three courses ('Smart Sensing', 'Smart Buildings', 'Smart Cities') and smaller hackathon challenges within each. Due to COVID-19 all of these had to take place entirely online, which was not ideal but gave a good base line for comparison regarding the following semesters. The first iteration of the summer semester course 'Critical Infrastructure and Digitalization' (CID) also had to take place entirely virtually and received quite positive feedback with regard to the chosen lecture and discussion format. In preparation of the second iterations for both semesters, the focus lay on ensuring blended components. For the winter semester, this meant merging the 'Smart Building' school content into the respective other schools and hosting one, cumulative in-person three-day hackathon event for participants of both schools. The focus on challenge-based learning was therefore also better implementable and further fine-tuned in the third iteration. Likewise for the second summer semester, workshops of the CID course were coupled with a three-day in-person program including a site-visit to a workshop-topic related model neighborhood and various social activities. International participants from the ide3a partner universities received scholarships to allow for this short-term mobility event. As also found in the comments of the feedback in chapter 3.2.2, this was very much appreciated and especially after two years of mostly involuntary virtual education such engagement and interaction seemed more important than ever.

The exact feedback and suggestions for improvements as utilized throughout the project are collected and presented in this report. They are found at the end of each semester section in chapter 3 and in chapter 4 'Lessons learned'. The ILOs and how they were measured are discussed in chapter 2.2.

Figure 2. Excursion CID 2022

Chapter 2: Overall Evaluation

2.1 Demographics

The ide3a project overall was able to reach many interested students already for the first iteration of the winter schools, with 474 students registering to participate initially. Capacity in the first schools were limited to 25 students per school, which was not reached due to several no shows. No shows remained to be an issue throughout the project, which is why the capacity was increased to 50 students per course in the following iterations. As observed in Table 1, interest in the schools remained stable across the semesters and attendance could be increased progressively. For the courses in 2022, it is likely that the pandemic has lessened students' enthusiasm to participate in a mostly virtual course as well. Interestingly the registrations for the semester long course were continuously lower than for the block courses.

Table 1. Participants Overview

		Registered	Attending	Students Completing Course	Dropouts	No-shows
2020	Smart Sensing	175	20	11	9	5
	Smart Buildings	134	23	18	5	2
	Smart Cities	165	16	5	11	9
	Total	474	59	34	25	16
2021	CID	58	46	36	3	7
	Smart Sensing	252	40	33	5	4
	Smart Cities	138	38	36	2	5
	Total	448	124	105	10	18
2022	CID	50	44	24	14	6
	Smart Sensing	185	30	26	4	10
	Smart Cities	287	28	23	5	11
	Total	522	102	73	23	27
	Total Overall	1,444	285	212	58	45

Drop-out Rate
Next to a rather high number of no-shows, drop-outs were an additional problem in all courses. Whilst numbers could be reduced somewhat from 2020 to 2021, especially with the 2022 CID course iteration, the problem reemerged. Given that at TUB students are free to choose their courses, and many students only attend a few lectures in the beginning of the course and then still decide to switch, this may have been a strong contributing factor outside of our control.

Overall, as also shown in Figure 3, we were successful in increasing the number of students completing the courses across the years and keep dropouts to a minimum. Unfortunately, no real insight could have been gained as to why students chose to register and then never showed up. After optimizing registration periods as close to the start of the courses as possible already,

it should not have been a schedule conflict. This increase in no-shows was also presumably the reason why 2022 took a slight dip in completion numbers.
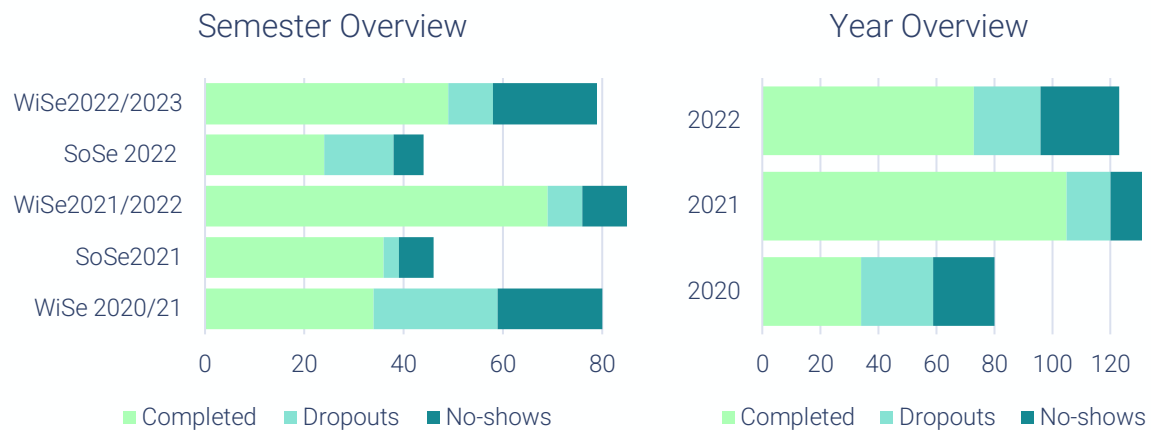

Figure 3. Semester and Year Overview of Course Demographics

University Affiliation

The majority of students engaged in the ide3a courses overall came from PoliMi, closely followed by TUB. Unfortunately, no students from DCU joined the courses, and numbers from CUT and NTNU were limited. For two of the courses students from the Hasso-Plattner Institute in Potsdam also joined.

Table 2. Final Participants' University Affiliation

		TU Berlin	PoliMi	HPI	DCU	CUT	NTNU	Total
2020	Smart Sensing	4	4	-	-	2	1	11
	Smart Buildings	4	13	-	-	1	-	18
	Smart Cities	4	-	-	-	1	-	5
2021	CID	23	2	11	-	-	-	36
	Smart Sensing	10	23	-	-	-	-	33
	Smart Cities	7	29	-	-	-	-	36
2022	CID	19	3	2	-	-	-	24
	Smart Sensing	14	11	-	-	-	1	26
	Smart Cities	6	17	-	-	-	-	23
	Total	91	102	13	-	4	2	212

Despite best efforts to maximize advertisement, attendance from CDU, CUT and NTNU could not be improved since the first iteration of the schools. Here, it is likely that the semester schedules are too different across universities. Unfortunately, no further insight was gained.

Study Programs

The goal to deliver multidisciplinary courses was reached not only from the content side. In total, students from 45 different study backgrounds participated across all courses. Find all different study tracks in Table 3 below.

Table 3. Study Backgrounds

Aeronautics and Astronautics	Integrated Mobility Planning
Architectural Design	IT-Systems Engineering
Architecture and Urban Design	Landscape Architecture
Automation and Control Engineering	Management Engineering
Biomedical Engineering	Materials Engineering and Nanotechnology
Building and Architectural Engineering	Mathematical Engineering
Business Informatics and Digitalization	Mechanical Engineering
Chemical Engineering	Mobility Engineering
Civil (Systems) Engineering	Physical Engineering
Civil Engineering (and Risk Mitigation)	Process and Environmental Engineering
Computational Engineering	Process Energy Engineering
Computer Science	Simulation and Visualization
Cybersecurity	Software Engineering
Data Engineering	Space Engineering
Electrical Engineering	Sustainable Architecture and Landscape Planning
Energy Management	Sustainable Manufacturing
Engineering and Water Management	Telecommunication Engineering
Environmental Engineering	Transportation Planning and Operation
Geoinformation Science	Urban and Regional Planning
Human Factors	Urban Development
ICT Innovation	Urban Management
Industrial Engineering and Management	Urban Planning and Policy Design
Information System Management	Water Engineering

2.2 Overall Evaluation – ILOs across Semesters

As part of the DAAD program "International Mobility and Digital Cooperation" (IMKD), the ide3a project's teaching activities focused on "Building methodological knowledge and digital competencies through the development of digital teaching and learning scenarios". To be able to measure the success of achieving this goal, these 'digital competencies' had to be better defined. To do so, we followed the 'Digital Competence Framework' published by the European Commission[1]. From the framework we identified the competence areas and specific skills that were relevant to the ide3a courses and modified the formulation, accordingly, following the provided guide[2].

Due to personnel changes, the ILOs for the ide3a courses were only defined in January 2021, which was after the first iteration of the school already took place. Therefore, in the subsequent evaluation, only the courses from 2021 and 2022 are evaluated using the ILOs.

As outlined in Figure 4, four competence areas and nine competences in total were defined. The 'Problem Solving' category is referred to as the 'core ILOs' in the rest of the report and represent the 'methodological knowledge' as aimed for by the IMKD program. Figure 4 also outlines in how far the courses were successful in increasing these competences in the students that responded to both the pre- and the post-course surveys. The bold check mark indicates where we could find statistically significant increases (at the 0.05 level).

		Competence Area 1: Information and Data Literacy		Competence Area 2: Communication and Collaboration			Competence Area 3: Digital Content Creation	Competence Area 4: Problem Solving		
		Assess the need for certain information or data sets and their relevance	Browse and adapt data sets in order to organise and process them	Select and navigate a variety of digital tools for collaborative processes	Share and present data, information and digital content through a variety of appropriate tools	Recognizing and conveying appropriate behavioural norms in international environments	Perform simulations and or data analysis (e.g. with Python, R)	Identify currently relevant technical problems within the 'digitalisation of critical urban infrastructures'	Identify problem-solving approaches to these problems	Identify synergies and interdependencies between critical urban infrastructure sectors"
2021	CID	⊕	⊕	⊕	⊕	⊕	⊕	☑	☑	☑
2021	Sensing	⊕	⊕		⊕	⊕	⊕	⊕	⊕	⊕
2021	Cities	⊕	⊕	⊕		⊕	⊖	☑	☑	☑
2022	CID	⊕	⊕	⊕	⊕	⊖	⊕	☑	☑	☑
2022	Sensing		☑	⊕	⊕	⊕	⊕	☑	☑	☑
2022	Cities	⊕	☑	⊕	⊕	⊕	⊕	☑	☑	☑
	Total		☑	☑	☑	☑		☑	☑	☑

Figure 4. Overview ILOs

Generally, the results presented in Figure 4 are quite positive. Even where no significant increases could be found, there were noticeable positive trends (indicated by the faint plus sign). The faint minus sign indicates non-significant decreases. These are interesting, because they do not seem to be systemic in the sense that they continued to occur across courses but only on two occasions. Especially given that they are not significant, they could represent cases in which students overestimated their skill in the pre-course survey, potentially as part of an experimenter bias. Given that the pre-course surveys were filled in during an introduction session of the course, students may have felt 'observed' and a slight need to answer questions in a favorable way.

The 'total' analysis was done treating all responses across all courses as one sample (n=50). In this analysis, seven out of the total 9 digital competences increased significantly. This evaluation paints a good overall picture of the educational formats within ide3a, and the continuous improvement undertaken over the years. The two competences that were not improved significantly, relate to very practical skills that were supposed to be tied to the workshops. The workshops were newly developed and continuously updated throughout the courses. Additionally, they were not the focus of the courses, which is why it is not surprising, although still unfortunate, that these ILOs were less successful. For more detailed feedback on the workshops see the relevant sections in chapter 3.

Results regarding the effectiveness of the courses in conveying the core ILOs to students (knowledge on 'relevant technical problems and problem-solving approaches within the digitalization of critical urban infrastructures' and the 'synergies and interdependencies between sectors') were successful in yielding significant results in almost every single ide3a course. It is also encouraging to see that during the last iteration of the smart schools, we could also achieve significant increases in an additional, more applied digital competence, 'Browse and adapt data sets in order to organize and process them'. This is a further indication, that the continuous improvement of the courses and workshops was effective.

The following chapter goes into detail on the individual semester evaluations and presents feedback received on the formats and workshops in addition to the ILOs.

Chapter 3: Semester Evaluations

3.1 Smart Schools

3.1.1 WiSe 2020/2021

Smart Sensing School WiSe 2020/2021
TUB central evaluation
Based on the feedback collected from the TU internal survey (n=8), the Smart Sensing School performed very well overall, even better than the average course offered at the Faculty of Mechanical Engineering and Transport Systems, at which the Smart Water Networks department is settled. Given that only 11 students attended the course, the response rate of 73% is quite high.

Speakers and teachers were rated very positively across most questions. 100% of respondents either agreed or strongly agreed that "the teacher spoke clearly and in an engaging manner", "regularly summarized the content", "clarified learning goals at the beginning of each class" and "presented the content coherently".

100% of respondents also either agreed or strongly agreed that felt they well supervised by teachers overall, and that content and organization related questions were answered clearly. Further, as can be observed in Figure 5, the exercises appeared to be helpful in understanding the content better, and teachers could explain the content well, too. Interesting to note is also, that the execution of the digital format was appreciated and 87.5% agreed that the content of the school is suited for digital formats.
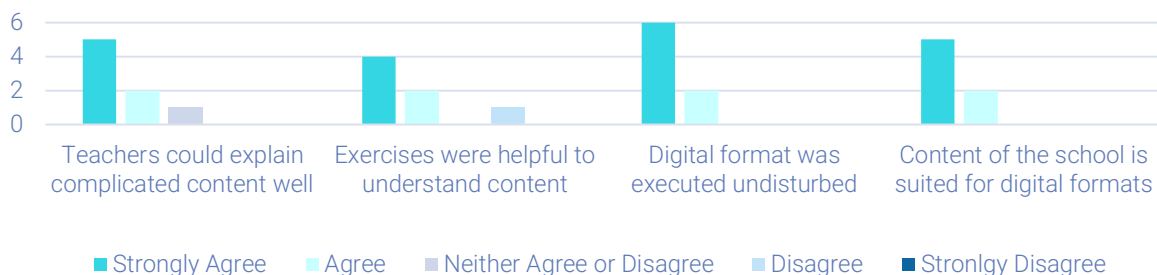
Figure 5. Overall Impressions Smart Sensing School (n=8)

There were no explicit comments or suggestions on what to improve from respondents.

Smart Building School WiSe 2020/2021

TUB central evaluation

Compared to the feedback collected for the Smart Sensing School, the Smart Building School performed a little less positive. Compared to the average course offered at the Faculty of Mechanical Engineering and Transport Systems, the feedback is slightly lower than average. However, with 9 respondents, the response rate for this school is quite low (50%).

Since there is almost consistently one indication of the lowest score for each question, the overall evaluation is skewed towards the negative. However, the distribution of responses within the positive range is also different to that of the Smart Sensing School. While 88.8% agree or strongly agree that "the teacher spoke clearly and in an engaging manner" and "presented the content coherently", respondents to larger degree only agree rather than strongly agree, indicating less enthusiasm in their response than it assumably was the case for the Smart Sensing school. 77.7% agree or strongly agree that the teacher "regularly summarized the content", and 66.6% further agree that they "clarified learning goals at the beginning of each class". 88.8% agree or strongly agree that they felt well supervised by teachers overall, and that content and organization related questions were answered clearly.

As seen in Figure 6, the pattern of response with a higher agree than strongly agree indication was also observed for the questions regarding the ability of the teachers to explain complicated content well. Especially noticeable is the reserved response to the question whether exercise were helpful to understanding the content. The execution of the digital format, however, was also appreciated in this course, although content was evaluated as less suited for digital formats, with only 66.6% agreeing or strongly agreeing.
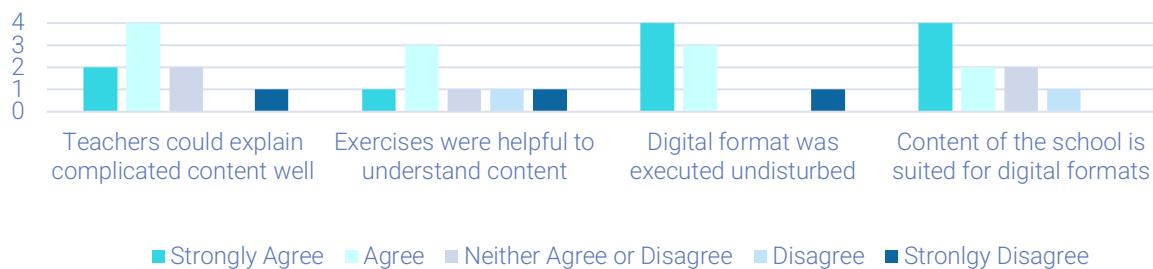

Figure 6. Format Impressions Smart Buildings School (n=9)

As for suggestions and further comments, some students indicated that the group work was unbalanced and that dropouts were causing issues in their workflow.

Ide3a internal evaluation

The response rate for the ide3a internal evaluation, which was sent out right after the completion of the school, was higher (77.8%) than for the TUB central evaluation. It was overall also slightly more positive. It cannot be said how many of the TU central evaluation respondents also completed this one. Of course, there is some overlap to be expected, meaning results between the surveys are not cumulative, but rather complementary.

As with the TUB central evaluation, one respondent consistently indicated negative responses or did not respond to questions at all, again skewing the overall evaluation slightly towards the negative. 85.7% of respondents nonetheless either agreed or strongly agreed that the course was well structured and that the organization and pre-information were sufficient. 92.9 % further indicate that the digital format of the course was well executed, with 71.4% even strongly agreeing. With regard to the amount of time spent for preparation, participation and follow-up, 85.7% state the effort was appropriate and 14.3% stating it was excessive. The net promoter score, calculated by subtracting the percentage of those unlikely to recommend the

event from those who strongly agree that they will, is quite high with 50%. Generally, the Hackathon format was additionally appreciated several times in individual comments.

However, when looking at the format more in detail, the distribution of answers becomes more scattered. While 71.4% still either agree (21.4%) or strongly agree (50%), that there was enough interaction and space to connect with others, 28.6% remain neutral or even disagree. About the same pattern is observed in the answers to the question whether students felt they connected well with others, as seen in figure 7. It seems like the majority of students connected well with each other, while about a quarter did not.

There might be a connection to the mixed responses regarding the question whether participants would have liked a more engaging and participatory style of lectures. With 42.9% agreeing and 28.6% remaining rather neutral, there seems to be potential for improvement.
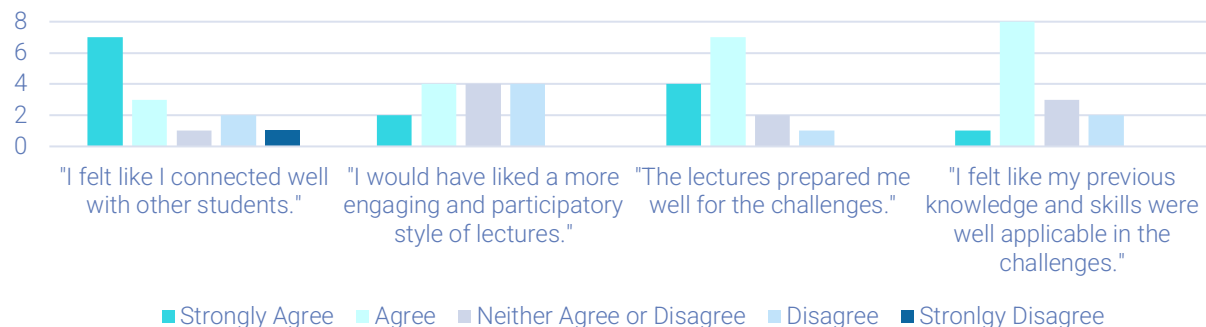
Figure 7. Format Impressions Smart Buildings School (n=14)

Similarly, for the last two questions displayed in Figure 7, although trending toward positive feedback, there is still room for improvement, with 28.6% not agreeing that the lectures prepared them well for the challenges. The more reserved responses to the final question also raise the question, whether they felt like their previous knowledge and skills were not applicable because they learned a lot instead or because they were struggling with the content. The former might be the case, since, as figure 8 shows, 92.9% either agree or strongly agree that the school gave them insights into new fields of knowledge and methods. 57.1% also state that they were not familiar with a lot of the content before taking part in the school. 85.7% further indicate that they have gained new competences through participation, and 71.4% agree that participating has also widened their digital communication skills.
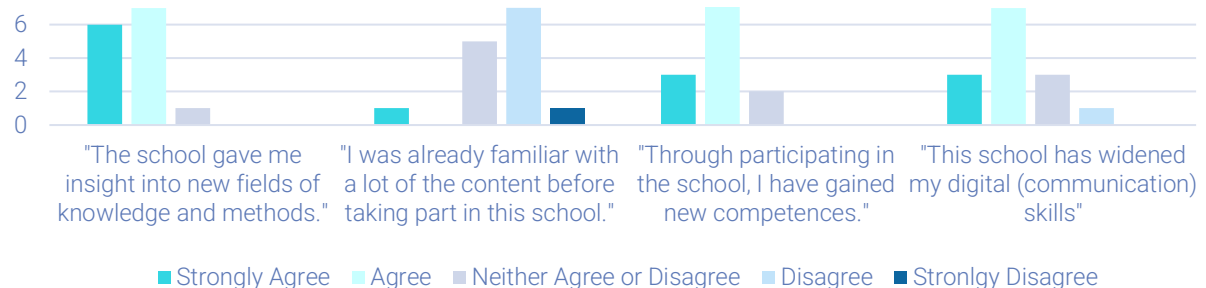

Figure 8 . Format Impressions Smart Buildings School (n=14)

Suggestions for improvements include again, making lectures more interactive and having the opportunity for a consultation hour after the hackathon and the final presentations.

Smart Cities School WiSe 2020/2021

ide3a internal evaluation

Unfortunately, since there were only 5 students completing this school, the evaluation also relies on the feedback of a low number of respondents, at least with a high response rate of 80%.

100% of respondents agree that the organization and pre-information about the course were sufficient. 100% also strongly agree, that the course was well structured, that the amount of time spent for preparation, participation and follow-up was appropriate and that the digital format was well executed. However, only 75% agree or strongly agree that there was enough space to connect with others, while 25% are rather neutral in their response. Nonetheless, 100% of respondents agree or strongly agree that they felt they connected well with other students, as seen in Figure 9. Interestingly enough, as for the Smart Buildings School, the opinions on a more engaging and participatory style of lecture are also quite dispersed for this school. Further, the responses for whether the lectures prepared them well for the challenges are also split between positive and neutral responses (50% each).
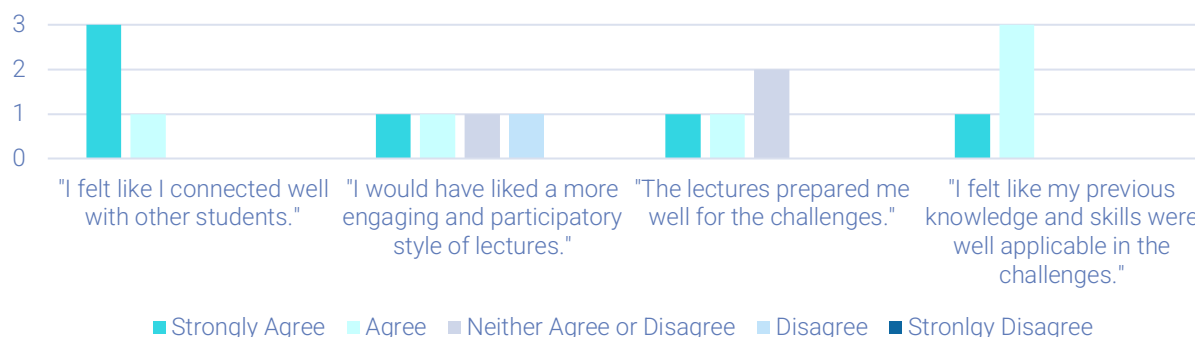
Figure 9. Content Impressions Smart Cities School (n=4)

As the only out of the three schools, this school's evaluation was based on previously formulated ILOs. These pertain mostly to digital competences gained during participation. As figure 10 shows, at least 50% felt that they have gained or expanded on all targeted digital competences through their participation in the school.
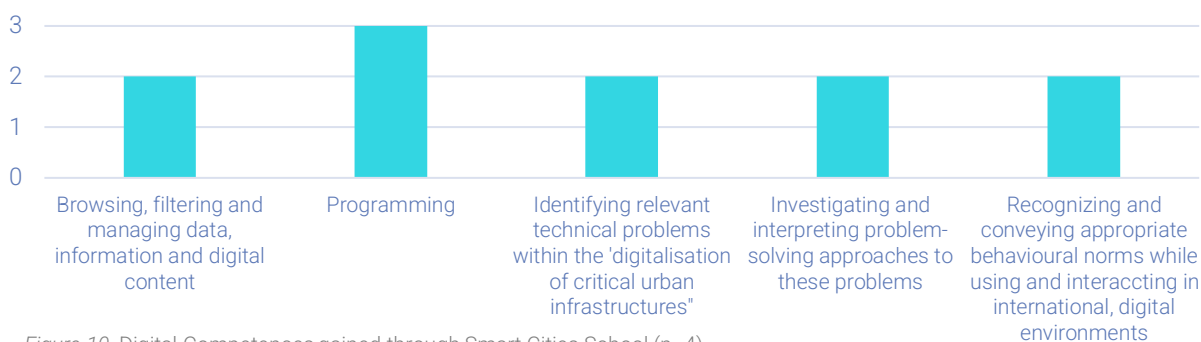

Figure 10. Digital Competences gained through Smart Cities School (n=4)

Even though 50% of students claim they were already familiar with a lot of the content, 100% still agree that the school gave them insights into new fields of knowledge and methods.
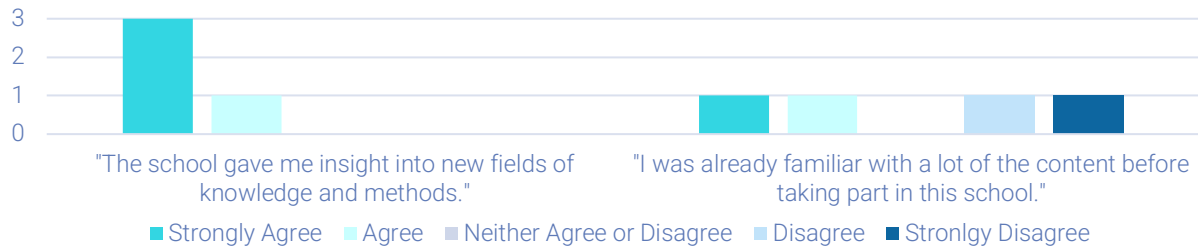
Figure 11 . Content Impressions Smart Cities School (n=4)

Suggestions for improvements hint to including more interactive parts such as the warm-up quizzes that were done within this school. Another comment suggested the lecture modules were too time intensive, especially done via the digital format. Some lectures were also too "specialized" for the commentator's background knowledge.

Main takeaways from feedback round

In order to discuss the previous evaluation and gather additional insights, all students who completed at least one school were invited to a feedback round. 3 students attended, and one of the students who completed more than one school sent feedback via email.

The main takeaways from the discussion with the students concentrated on feedback regarding changes to the format. All agreed that more time to digest and get more familiar with the content would be beneficial. In general, the idea to stretch out the school over several weeks and sessions was received quite positively.

There were different opinions as to whether pre-recorded lectures would be a good idea. As the number of attending students was quite low, it is not possible to say how the rest of the students would find such an approach. However, all agreed that the most valuable part of live lectures is the opportunity to ask questions and if seminars or workshops were more geared toward this kind of interaction, pre-recorded lectures seemed acceptable. This also went along with the wish of students to receive more literature in advance to prepare better for the content of the course and challenges. Likewise, they were asking to include, where relevant and possible tutorials and instructions for tools to be used during the challenges. The journal club, which was only included in the Smart Buildings School was also mentioned as a valuable addition, especially because it combined engagement with skills training.

Group evaluations, in general were regarded as a good format, but there were some suggestions to include more 'check-ins' with the teachers, which would increase engagement and make it easier for teachers to get an overview of whether work is shared equally among group members.

Lastly, all would have preferred a face-to-face Hackathon, especially because it would aid in commitment and engagement of group members. A similar point was also the use of warm-ups and teambuilding, which was highly appreciated by attendees of the last school and should be used increasingly so to foster group cohesion and commitment.

As indicated in Figure 12, the intrinsic motivation of attendees was the main reason for attending and the coming iterations of schools should take advantage of this and build on it with high levels of engagement and team-building exercises, especially since 75% of the Smart Cities School attendees, also indicated 'meeting international students' as one of their motivations for participating. This question was not asked in the evaluations of the first two schools, which is why it is not included in Figure 12.
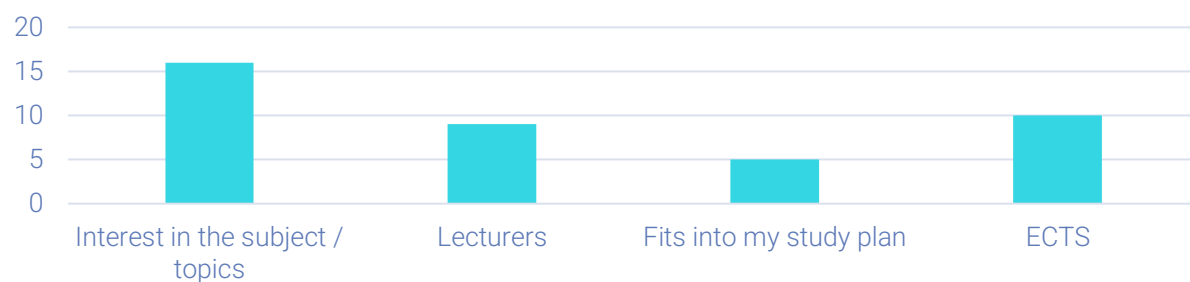

Figure 12. Reasons for attending Smart Buildings & Smart Cities School (n=18)

3.1.2 WiSe 2020/2021 Lessons learned…

Overall, the first iteration of schools within ide3a was successful and rated very positively. Students showed
- a high level of intrinsic motivation as reasons for participating
- great appreciation of the interdisciplinarity and internationality of the courses
- a gain in or expansion on digital competences

From an organisational perspective
- it makes more sense to limit participation to ide3a partner university students
- the hackathon format should remain within the school structure, rather than be promoted as an 'event'

With the third and fourth points especially, core goals of the ide3a project are being addressed, the challenge-based learning approach therefore seems to be going in the right direction.

… and suggestions for next year

Based on the feedback evaluated in this summary, a few suggestions for next year's format can already be made. These should help to increase the aforementioned positive outcomes and lower the dropout rates as well. More detailed guidelines for their implementation will follow. More attention should be payed to:
- a "challenge-based learning" didactic framework and clearly defined ILOs as base
- including the opportunity for real-life applicability and networking with partners
- conceptualizing a more flexible schedule and registration process to allow for parallel deadlines and engagements
- including more opportunities for interaction and teambuilding in the schedule
- engaging more students from the ide3a partner universities

Finally, as for a fully digital or blended format of the schools, the feedback suggests that the current format was already well executed. Nonetheless, an in-person Hackathon is likely to add an incentive to complete the school and foster group cohesion if possible next semester. To build on the positive experiences of this semester though, a blended format with a digital preparation phase (including lectures and skills building seminars) for example could be interesting to explore.

Notes on Evaluation

As mentioned before, each school was evaluated using a slightly different format. The goal for next year therefore is to have a coherent evaluation format across all three schools. Given that their implementation should be more heavily guided by ILOs than this years' schools, the evaluation of these outcomes will also be more conclusive. This could include comparison of pre- and post- school surveys to better understand what kind of competences were already present before participation, and which were a direct result of participating in the schools. Another possibility is to include the assessments of students in the evaluation to identify direct evidence of achieved learning outcomes, rather than relying on their reflection only. Finally, with a hopefully lower drop-out rate, the evaluation can be based on the feedback of more students and also be increased in its representativeness.

Smart Sensing School WiSe 2021/2022

General / Format

The response rate for the post-course survey for the Smart Sensing school (48.5%) was lower than that of the pre-course survey (70%) but showed an improvement from last year's number of responses. Of the 16 respondents in the post-course survey, 80% agreed or strongly agreed that the course was well structured and that the pre-information about the course was sufficient (87.5%). 87.5 % further indicate that the digital format of the course was well executed, with 62.5% even strongly agreeing.

With regard to the amount of time spent for preparation, participation and follow-up, 85.7% state the effort was appropriate and 14.3% evaluating it as relatively small, no one indicated it to be excessive. The net promoter score, calculated by subtracting the percentage of those unlikely to recommend the event from those who strongly agree that they will, is 43.7, with 43.8% even indicating full 10 out of 10 points on agreement.

The18revious18n format (challenge-based learning) was rated very positive by 81.3%, indicating they really enjoyed it and wished there were more events like this. 31.3% also indicated that they were struggling a bit with group composition and output, and one person additionally with the time frame.

In terms of group work cooperation, the digital group work components did not receive any negative feedback, with 81.3% indicating they thought it went easily, and 18.8% being indifferent. The output of the group work during the hackathon however, reflected the earlier mentioned struggles, with 18.8% indicating it was ineffective. 62.5% on the other hand said it was 'very' or 'extremely effective'. Although the large majority of respondents (86.6%) indicated that they were happy with the group size, 12.5% also indicated they were too big.

Lastly, the feedback that was given during the presentations and on moodle was constructive and valuable to 100%, but 37.5% would have liked even more feedback overall.

These answers are also reflected, when looking at more detailed questions on the format. While 75 % still either agree (18.8%) or strongly agree (56.3%), that there was enough interaction and space to connect with others, 12.5 % remain neutral. Somewhat related are the answers to the question whether students felt they connected well with others, which display a similar trend, as seen in Figure 13. The majority strongly agreed that internationality was valuable to them though.
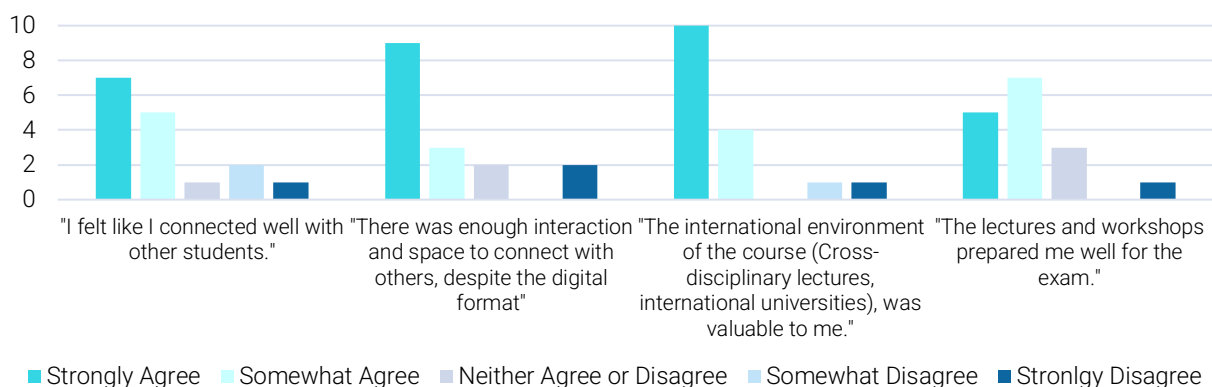

Figure 13. Format Impressions Smart Sensing school (n=16)

Similarly, for the last question displayed in Figure 13, although trending toward positive feedback, there is still room for improvement, with 25.1% not agreeing that the lectures and workshops prepared them well for the exam. Further comments and evaluation on the workshops are found in the next section.

Workshops

General
Nonetheless, 87.5 % agreed (50%) or strongly agreed (37.5%) that the lectures sparked their interest in the subject and found them a valuable addition to the schedule.

93.8% agreed or strongly agreed (56.3%) they could follow the workshops of the school well. Only one student strongly disagreed. 93.8% further indicated that the workshops helped them understand the lecture content better.

Journal Club
Easily understood: 68.8%
Troubles understanding some parts: 25%
Valuable addition to the schedule (87.5%)

Design Thinking
Easily understood: 62.5%
Troubles understanding some parts: 31.3%
Valuable addition to the schedule (87.5%)

Sensitivity Analysis Workshop
Easily understood: 50%
Troubles understanding some parts: 37.5%
Content was too difficult: 6.3%

Arduino Workshop
Easily understood: 68.8%
Troubles understanding some parts: 18.8%
Content was too difficult: 6.3%

Smart Sensing School WiSe 2021/2022
Competences (Pre / Post Comparison)

Core intended learning outcomes (ILOs)

Only 8 students' answers could be compared before and after. Unfortunately, for the Smart Sensing students the core ILOs results are slightly disappointing. For none of the ILOs could a significant increase be found, despite slight changes in response patterns (Pre-Survey: M = 2.25, SD = 1.28; M = 1.63, SD = .744; M = 2.0, SD = .756) (Post-course survey: M = 2.88, SD = .354; M = 2.75, SD = .886; M = 2.38, SD = .518). For the 'Problem-solving approaches' ILO, results are almost significant (t(7) = 2.183, p = .065), whilst the other two 'Currently relevant problems' and 'Synergies' remain far from it (t(7) = 1.488, p = .180; t(7) = 1.58, p = .285, respectively). Figures 14 and 15 present the results visually. The darker the color, the better the understanding.
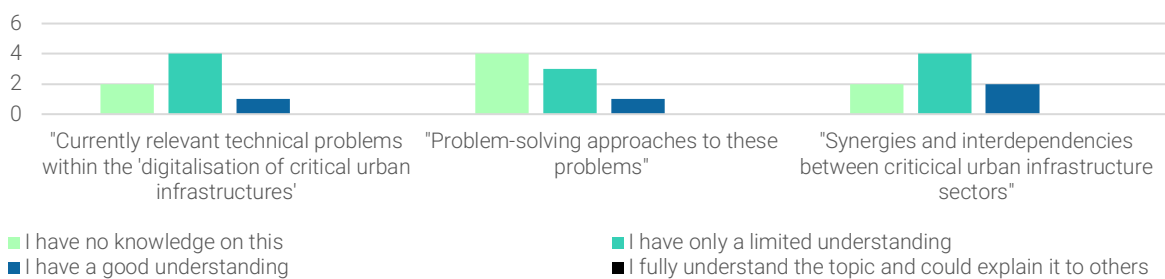
Figure 14. before ILOs before taking Smart Sensing (n=8)
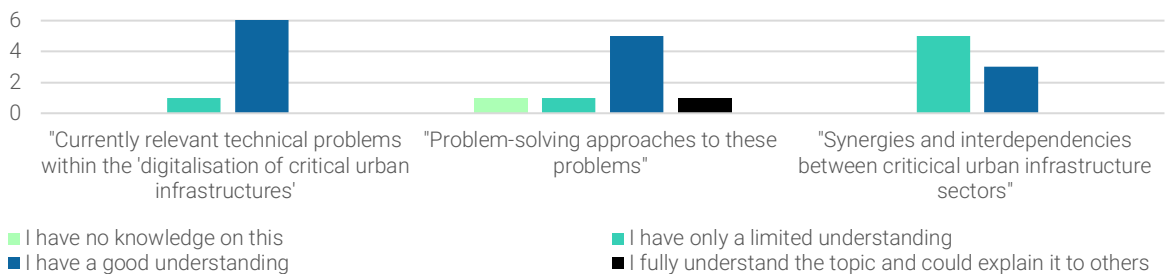
Figure 15. Core ILOs after taking Smart Sensing (n=8)

Despite the results not being statistically significant, the percentage of students indicating that they have a good understanding of 'Currently relevant technical problems' after taking the course (85%) is much higher than before the course (14%).

Competences (Pre / Post Comparison)

Digital competences

The same results are observable for the digital competences, with none of the comparisons of listed skills being close to significant results. Figures 16 and 17 show the minimal shifts that did occur. Again, the darker the color, the better the understanding.
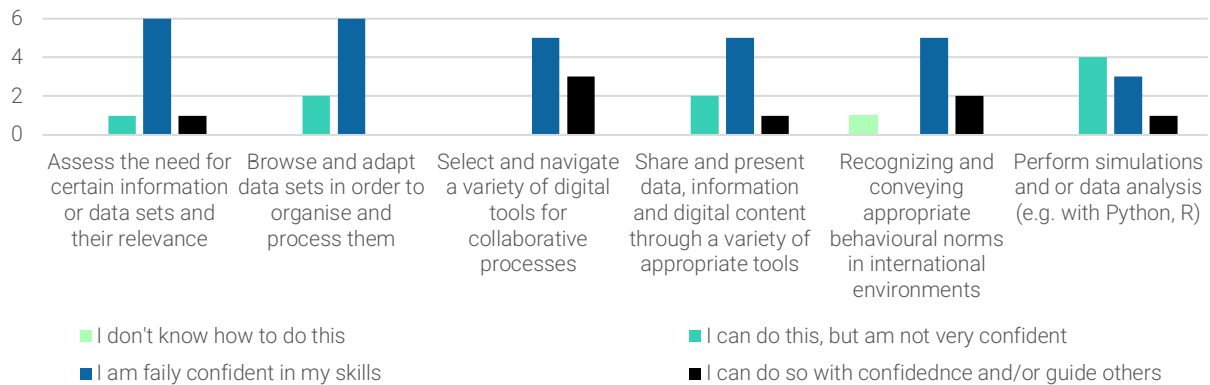

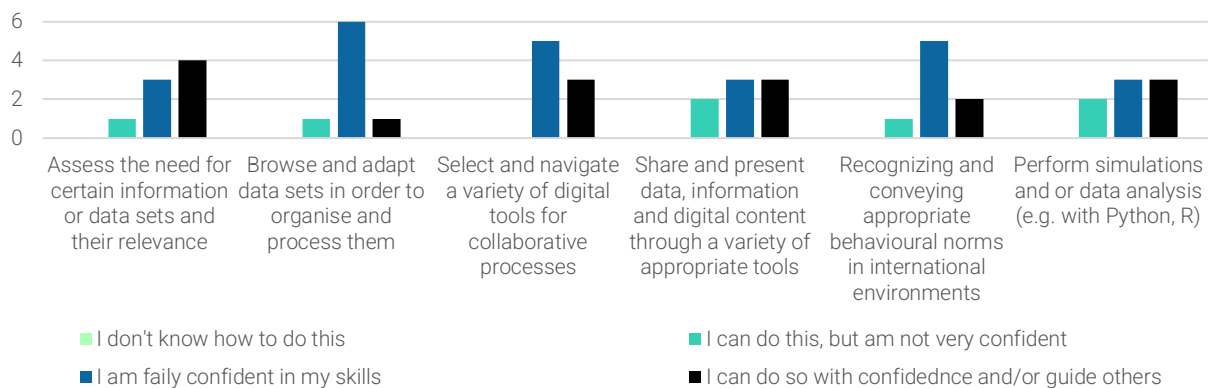*Figure 16.* Digital competences before taking Smart Sensing (n=8)

Figure 17. Digital competences after taking Smart Sensing (n=8)

Given that the results are similar to those of the CID course, it seems that more emphasis on all of the mentioned skills need to be given in curating the workshop and lecture content. However, it is also noticeable that students in this course indicated fairly high confidence levels before even taking the course, possibly influencing results. Also interesting to note, as seen later, confidence levels appear to be slightly higher in these students prior to taking the course than for the Smart Cities students (not significantly though).

Smart Sensing School WiSe 2021/2022
Competences (Pre / Post Comparison)

Views on competences

Before and after the course students were also asked how important they believe the competences above are and how they personally relate to multidisciplinarity and other disciplines. As seen in the figures below, students gave high importance to the mentioned competences and multidisciplinarity already before taking the course. Therefore, none of the comparisons of the views on competences and multidisciplinarity resulted in significant paired sample t-test output. As observed in Figures 18 and 19, there are only very small changes in response patterns. (Here the legend is reversed from the previous figures, and lighter colors indicate stronger agreement with statements).
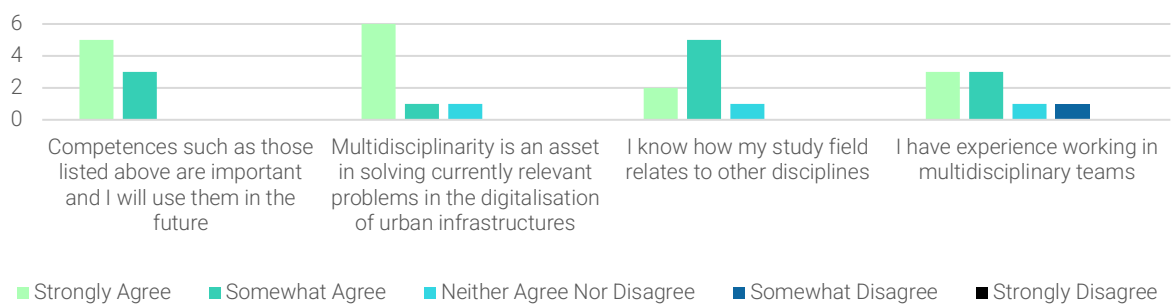
Figure 18. Views on competences before taking Smart Sensing (n=8)
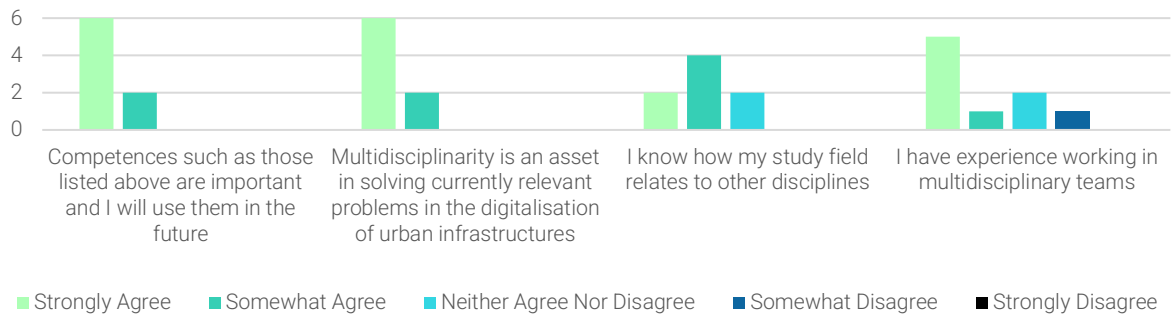
Figure 19. Views on competences after taking Smart Sensing (n=8)

These results are further indication that students who are interested in the ide3a courses, already have a high appreciation for multidisciplinary problem solving and digitalization.

Smart Cities School WiSe 2021/2022

General / Format

The response rate for the post-course survey for the Smart Cities school (38.9%) was again lower than that of the pre-course survey (78.9%). Of the 14 respondents in the post-course survey, 76.9% agreed or strongly agree that the courses were well structured and that the pre-information about the course was sufficient (46.2%). 69.2 % further indicate that the digital format of the course was well executed, while 15.4% remain neutral and another 15.4% slightly disagree.

With regard to the amount of time spent for preparation, participation and follow-up, 69.2% state the effort was appropriate, 23.1% evaluating it as relatively small, and one student indicated it to be excessive. The net promoter score, calculated by subtracting the percentage of those unlikely to recommend the event from those who strongly agree that they will, is 43.7, with 21.4% even indicating full 10 out of 10 points on agreement. This is slightly lower than for the Smart Sensing school.

The hackathon format (challenge-based learning) was rated very positively by 85.7%, indicating they really enjoyed it and wished there were more events like this. 14.3% also indicated that they were struggling a bit with group composition and output, and 21.4% additionally with the time frame.

In terms of group work cooperation, the Smart Cities school also received slightly more negative reviews than the Smart Sensing school, with only 35.7% indicating they thought digital group work components went easily, 50% being indifferent and 14.3% describing it as somewhat difficult. The output of the group work during the hackathon however, performed a little better, with 50% saying it was 'very' or 'extremely effective' and only one person indicating it to be ineffective. Also regarding group size, views are slightly more negative for the Smart Cities school, with 35.7% of respondents indicating they were too big, and 64.3% indicating they were happy with the size.

Lastly, the feedback that was given during the presentations and on moodle was constructive and valuable to 100%, but 28.6% would also have liked even more feedback overall.

These answers are also reflected, when looking at more detailed questions on the format. While 66.7% strongly agree that there was enough interaction and space to connect with others, 33.3 % remain neutral. Related are the answers to the question whether students felt they connected well with others, which surprisingly are more positive, as seen in Figure 20. The majority also agreed that internationality was valuable to them.
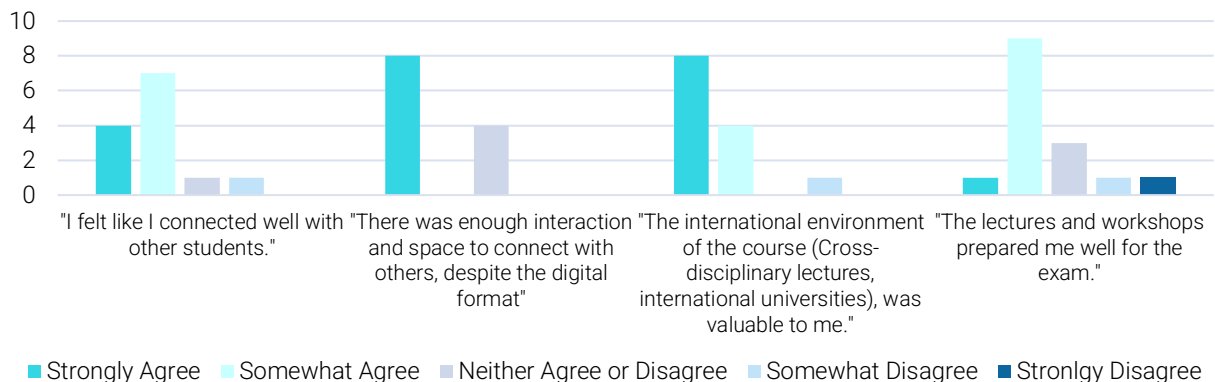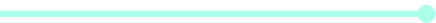

Figure 20. Format Impressions Smart Cities school (n=14)

Similarly to responses of the Smart Sensing school, for the last question displayed in Figure 20, there is still room for improvement, with 28.5% not agreeing that the lectures and workshops prepared them well for the exam. Again, further comments and evaluation on the workshops are found in the next section.

Workshops

General
Nonetheless, 87.5 % agreed (50%) or strongly agreed (37.5%) that the lectures sparked their interest in the subject and found them a valuable addition to the schedule.

78.6% agreed or strongly agreed (7.1%) they could follow the workshops of the school well. Only one student somewhat disagreed. These percentages are a little less convincing than those for the Smart Sensing school. Still, 71.4% indicated that the workshops helped them understand the lecture content better.

Journal Club
Easily understood: 71.4%
Troubles understanding some parts:
Valuable addition to the schedule: 78.6%

Design Thinking
Easily understood: 64.3%
Troubles understanding some parts: 7.1%
Valuable addition to the schedule: 92.9%

Urban Stormwater Systems and Green-Blue Infrastructure – SWMM Tutorial
Easily understood: 7.1%
Troubles understanding some parts: 35.7%
Content was too difficult: 28.6%

Simulating Mobility Systems – SUMO Tutorial
Easily understood: 14.3%
Troubles understanding some parts: 42.9%
Content was too difficult: 14.3%

Additional Comments:

"A crash course on the world of coding would have helped; for someone who doesn't know the first thing about these there were a lot of technical words etc some people had no knowledge of so it was even difficult to download or run stuff to prepare for the workshop by ourselves."

"In my personal feeling the simulation workshops should be better connected to the lecture and provide examples from real life. The numbers in the output from the first glance look like random numbers and it was hard to understand what to do with this output."

Competences (Pre / Post Comparison)

Core intended learning outcomes (ILOs)

Only 9 students' answers could be compared before and after. For the core ILOs regarding the knowledge on 'relevant technical problems and problem-solving approaches within the digitalization of critical urban infrastructures' and the 'synergies and interdependencies between sectors' results are very positive for the Smart Cities school. All respondents effectively increased their knowledge on all three domains from the pre-course survey (M = 1.89, SD = .782; M = 1.89, SD = .928; M = 1.67, SD = .707) to the post-course survey (M = 2.89, SD = .928; M = 2.56, SD = .726; M = 2.56, SD = .726) , with results even being statistically significant (t(8) = 4.24, p = .003; t(8) = 2.82, p = .022; t(8) = 4.44, p = .002 respectively). Figures 21 and 22 also show this quite nicely visually. Here again, the darker the color, the better the understanding.
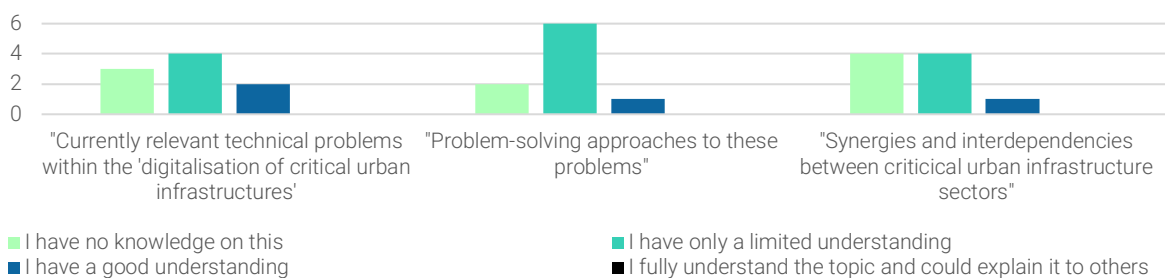
Figure 21. Core ILOs before taking Smart Cities (n=9)
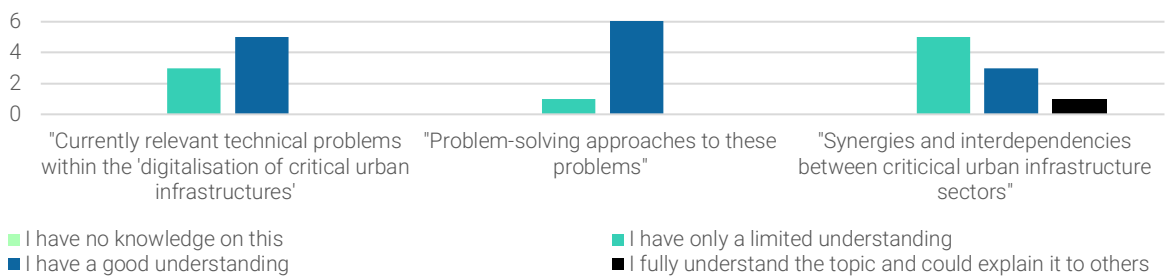
Figure 22. Core ILOs after taking Smart Cities (n=9)

Interestingly, 31.3% indicated that they were already familiar with a lot of the content before taking part in the school, as opposed to 68,8% of students who weren't. This might explain why in comparison to the CID course the shift in learning was slightly smaller.

Smart Cities School WiSe 2021/2022
Competences (Pre / Post Comparison)

Digital competences

As for the digital competences that ide3a aims to convey, results are, also for the Smart Cities school slightly disappointing. Although there are slight increases in the knowledge for some competences (such as the third, fourth and fifth in Figures 23 and 24), none of the competences results are statistically significant in a paired sample t-test. Again, the darker the color, the better the understanding.

■ I don't know how to do this
■ I am faily confident in my skills
■ I can do this, but am not very confident
■ I can do so with confidednce and/or guide others
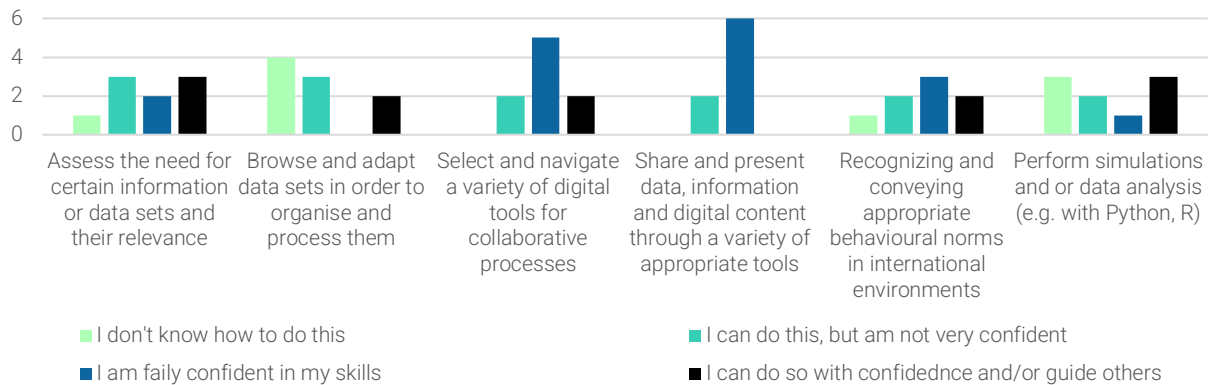
Figure 23. Digital competences before taking Smart Cities (n=9)

■ I don't know how to do this
■ I am faily confident in my skills
■ I can do this, but am not very confident
■ I can do so with confidednce and/or guide others
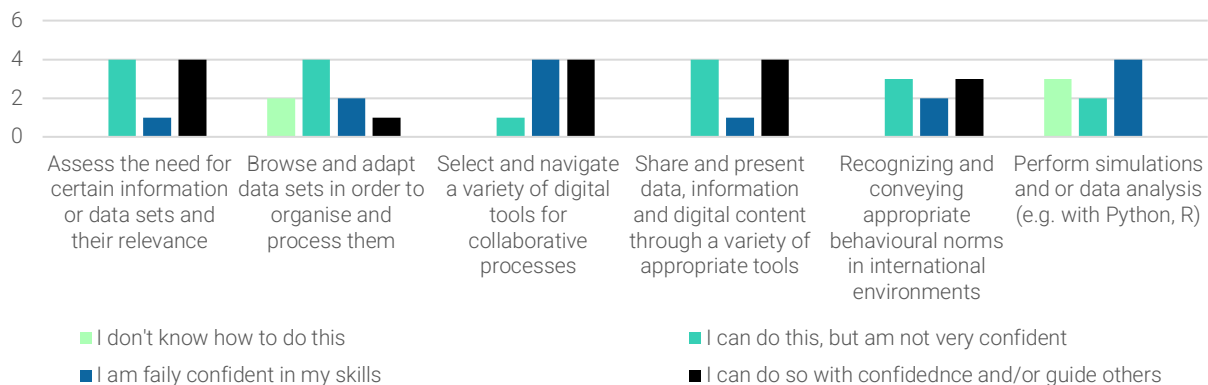
Figure 24. Digital competences after taking Smart Cities (n=9)

Interestingly, confidence in performing simulations even decreased for some (see for example the far right competence). Given that the results are similar to those in the CID course, it seems that more emphasis on all of the mentioned skills need to be given in curating the workshop and lecture content. However, it is also noticeable that students in this course also indicated fairly high confidence levels before even taking the course, possibly influencing results.

Competences (Pre / Post Comparison)

Views on competences

Similar to the results of the Smart Sensing course, students again gave high importance to the mentioned competences and multidisciplinarity already before taking the Smart Cities course. Therefore, none of the comparisons of the views on competences and multidisciplinarity resulted in significant paired sample t-test output. As observed in Figures 25 and 26, there are only very small changes in response patterns; if anything, students tended to agree less strongly with statements after the course. (Here the legend is reversed again from the previous figures, and lighter colors indicate stronger agreement with statements).

■ Strongly Agree ■ Somewhat Agree ■ Neither Agree Nor Disagree ■ Somewhat Disagree ■ Strongly Disagree
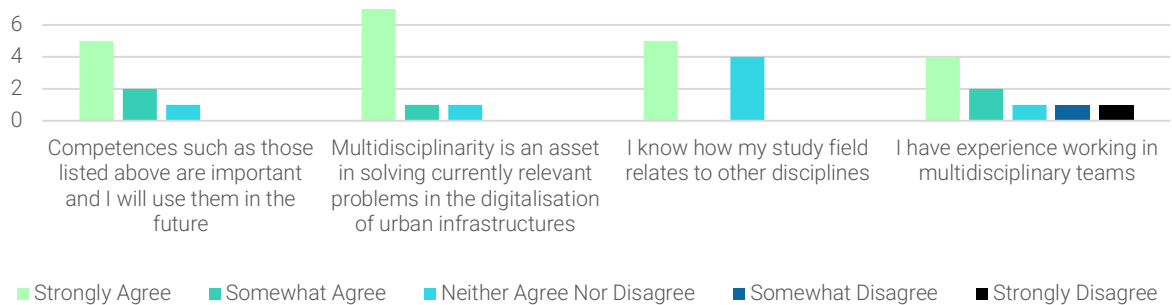
Figure 25. Views on competences before taking Smart Cities (n=9)

■ Strongly Agree ■ Somewhat Agree ■ Neither Agree Nor Disagree ■ Somewhat Disagree ■ Strongly Disagree
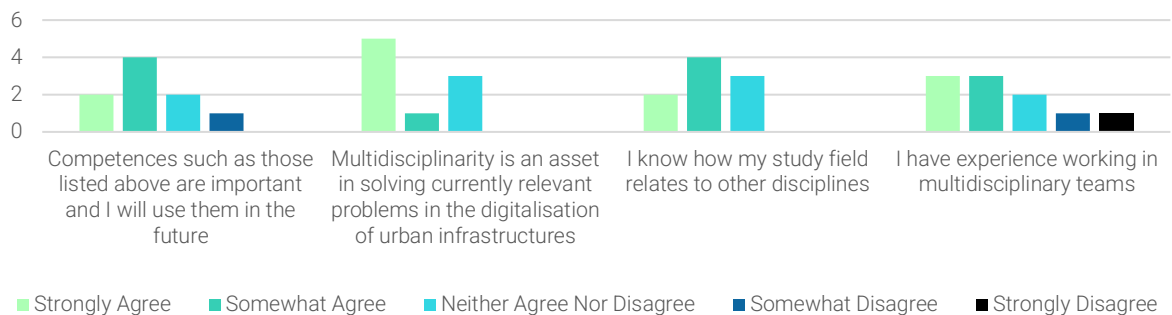
Figure 26. Views on competences after taking Smart Cities (n=9)

One finding worth mentioning here, is that in comparison to the Smart Sensing school, students in the Smart Cities school evaluate the competences significantly less important after taking the course than before [$F_{(1,15)}$ = 6.63, p = .021]. Explanations for this are unclear (one could be devaluing importance of a certain skill one has previously overestimated themselves in due to cognitive dissonance), but either way this further strengthen the importance of curating workshops that highlight the importance of the ILOs.

Logistics (Across Both Schools WiSe 2021/2022)

Communication
The most effective communication tool for advertisement across both schools was again E-mail, with 81% of respondents finding out about the schools via e-mail communication. Just as for the previous CID course, (nearly) none mentioned Social Media outlets, so the current communication strategy should be adjusted accordingly.
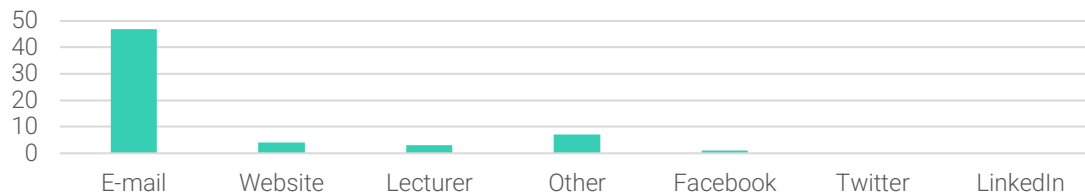

Figure 27. 'Where did you find out about this course?' (n=58)
Note: Multiple answers possible

Those in the 'other' category named friends and TUB MOSES.

Motivation
As with the previous ide3a courses, the highest-ranking motivation for participating in the CID course was interest in the subject (89% of respondents). Meeting international students again ranked second (48%).
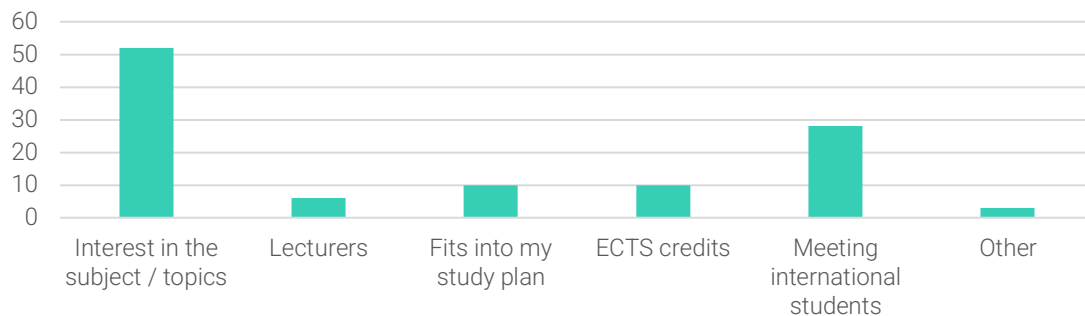
Figure 28. 'Why did you decide to participate in this course?' (n=58)
Note: Multiple answers possible

"Which parts did you find especially successful and should be retained?"
"International experience, working in groups, effective communication."
"Journal Club" (2x)
"The group structure"
"All the Workshops" (2x)
"Hackathon" (2x)
"Organization, Tools like slack, Workshops, Podcasts etc."
"Well organized, very helpful, dynamic and friendly organizers, turned out as promised"
"The basic idea to unify multidisciplinary, international people and participate in challenges"
"Edge Computing"
"Design Thinking"

"What parts did you find bothersome and should be improved?"
"Content of lectures not so coherent to the challenge theme"
"Technical part about pumps and measurements"
"Hackathon task explanation, communication of course requirements or checking abilities (maybe application is required or passing a pre-test as I know it from other courses), accommodation etc is paid by Organisation directly (people don't get the money, just the goods like accommodation, flight etc)"

"Docker"
"Was difficult to follow workshops without knowledge of coding before. Also, as an architect it was difficult to put input in the hackaton, but i'm not sure how or if this can be improved exactly"

3.1.4 WiSe 2021/2022 Lessons learned…

Overall, the evaluation of the Smart Sensing and Smart Cities schools yielded again, very positive outcomes. Especially the high attendance numbers and much improved drop-out rate (only 8.9% overall in comparison to 42.3% last year) are successes in themselves. Also, in terms of response rates there were slight improvements in comparison to last year (48% and 39% for post-course survey).

With only slight deviations within each school, students mostly indicated that the digital components were well executed and that they enjoyed the hackathon (challenge-based learning) format. The large majority also thought group sizes were fine and cooperation was effective. Further, 98.8% of Smart Sensing and 71.4% of Smart Cities respondents indicated that the workshops helped them understand the lecture content better. Regarding the group size, 31% and 14% struggled a bit with group composition and output and 28% also with the time frame. Perhaps the schedule or expectations of the hackathon can be adjusted or managed better next year to accommodate this feedback. Speaking of feedback, 37.5% and 28.6% in each school also wished for more feedback overall, so this should be considered as well.

The workshops overall received quite positive ratings in the comments but are also site of necessary improvements given the low improvement of digital competences across pre- and post-course measurements. One simple improvement would be to frame the workshops in terms of these competences to allow students to better understand what they refer to while taking the survey and therefore enable them to better reflect on how they handled that certain aspect of the course. A similar framing should be done with the pre-course survey to ensure that students do not feel the need to 'prove' their knowledge and therefore overestimating their skills and biasing the statistical outcome.

During the evaluation of the CID course the insignificant improvements on the digital competences could still be explained by the course's different focus on knowledge transfer rather than skills. The fact that the school scored similar to the CID course indicates that the workshops themselves should be re-worked to ensure consistency with intended learning outcomes. Even though majorities of each school agreed the workshops helped them in understanding the lecture contents better, about 25% in each school did not feel that the workshops prepared them well for the exam. Some comments also point to a missing coherence between exam (challenge) and lecture/workshop content. More emphasis should be placed on this coherence in next year's schedule, by **formulating the challenges first** and letting workshop and lecture content follow.

Notes on Evaluation

As mentioned before, the response rate is still too low to confidently generalize the findings in this report. One suggestion to improve this could be to incentivize post-course survey participation by setting a price (could be similar to one of the hackathon prizes).

The other important issue that should be addressed is the reframing of competences in two important aspects. One, through explicitly mentioning competences in workshops and lectures and explain how the content will teach them this skill. And secondly, adding a disclaimer to the pre-survey that responses are anonymous and skill level in no way influences course performance should ensure that students do not feel the need to 'prove' their knowledge and overestimate their skill level.

Smart Sensing School WiSe 2022/2023

General / Format

The response rate for the post-course survey for the Smart Sensing school (50%) was slightly higher than last year, and similar to the response rate of the pre-course survey (46.7%). Of the 13 respondents in the post-course survey, 100% agreed or strongly agreed that the course was well structured and that the pre-information about the course was sufficient. 91.7% % strongly agree that the digital format of the course was well executed, one respondent remained neutral.

With regard to the amount of time spent for preparation, participation and follow-up, 83.3% state the effort was appropriate and 16.7% evaluating it as relatively small, no one indicated it to be excessive. The net promoter score, calculated by subtracting the percentage of those unlikely to recommend the event from those who strongly agree that they will, is 60, with 60% even indicating full 10 out of 10 points on agreement.

The hackathon format (challenge-based learning) was rated quite positively by 61.5%, indicating they really enjoyed it and wished there were more events like this. 15.4% also indicated that they were struggling a bit with group composition and output, and 30.8% additionally with the time frame.

In terms of group work cooperation, the digital group work components did not receive any negative feedback, with 50% indicating they thought it went easily, and 50% being indifferent. The output of the group work during the hackathon, was rated similarly, with 58.3% saying it was 'very' or 'extremely' effective'. The remaining 41.7% called it 'moderately effective'.

In comparison to all other courses, the questions around personal engagement were the most positive yet. 100% of respondents either agree (41.7%) or strongly agree (58.3%) that there was enough interaction and space to connect with others. The answers to the question whether students felt they connected well with others, which display a similar trend, as seen in Figure 29. Almost all respondents also strongly agreed that internationality was valuable to them.
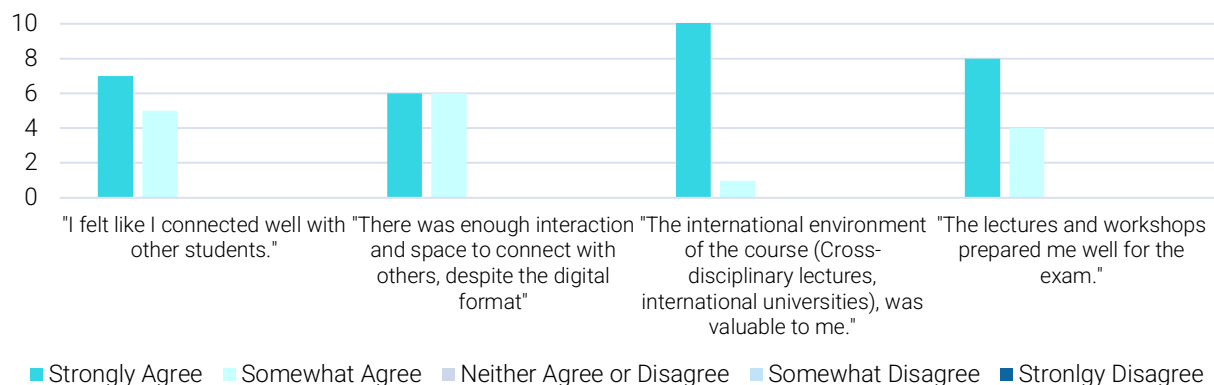

Figure 29. Format Impressions Smart Sensing school (n=12)

As an additional improvement to previous responses, 100% agreed or strongly agreed that the lectures and workshops prepared them well for the exam. More detailed evaluations on the workshops follow in the next section.

Workshops

General

92.3 % agreed (46.2%) or strongly agreed (46.2%) that the lectures sparked their interest in the subject and found them a valuable addition to the schedule. One respondent remained neutral.

92.3 % agreed or strongly agreed (69.2%) they could follow the workshops of the school well, which again is an improvement from last year's responses. Only one student somewhat disagreed. 92.3% further indicated that the workshops helped them understand the lecture content better. One respondent remained neutral.

Journal Club
Easily understood: 100%
Troubles understanding some parts: NA
Valuable addition to the schedule: 88.5%

Design Thinking
Easily understood: 80%
Troubles understanding some parts: 20%
Valuable addition to the schedule: 84.6%

Sensitivity Analysis Workshop
Easily understood: 40%
Troubles understanding some parts: 60%
Content was too difficult: NA

Resilient IoT Networks Workshop
Easily understood: 60%
Troubles understanding some parts: 30%
Content was too difficult: 10%

Competences (Pre / Post Comparison)

Core intended learning outcomes (ILOs)

Only 9 students' answers could be compared before and after. All core ILOs regarding the knowledge on 'relevant technical problems and problem-solving approaches within the digitalization of critical urban infrastructures' and the 'synergies and interdependencies between sectors' were successfully conveyed in the last iteration of the Smart Sensing school. All respondents effectively increased their knowledge on all three domains from the pre-course survey (M = 2.00, SD = .500; M = 1.55, SD = .726; M = 1.11, SD = .333) to the post-course survey (M = 3.22, SD = .667; M = 3.11, SD = .601; M = 2.78, SD = .441) , with results even being statistically significant (t(8) = 5.500, p = .001; t(8) = 8.854, p < .001; t(8) = 10.000, p < .001 respectively). Figures 30 and 31 show the effect visually. The darker the color, the better the understanding.
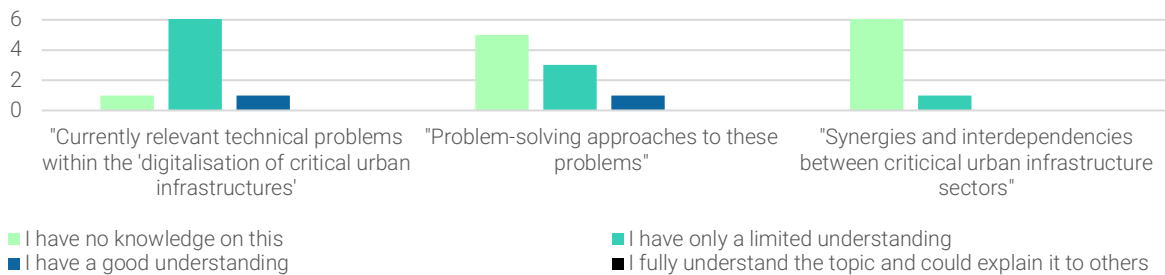
Figure 30. Core ILOs before taking Smart Sensing (n=9)
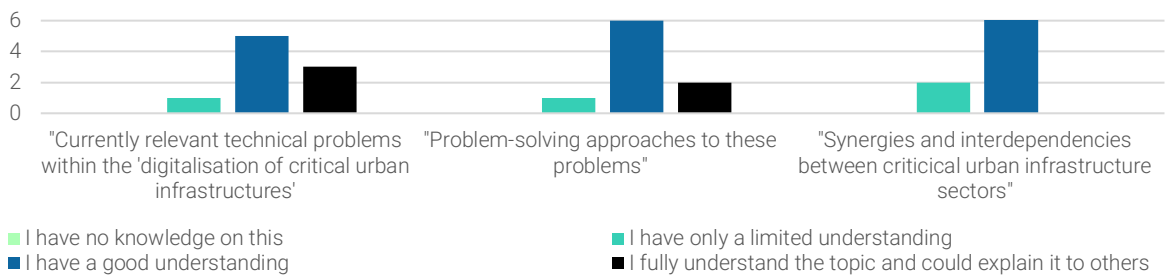
Figure 31. Core ILOs after taking Smart Sensing (n=9)

Competences (Pre / Post Comparison)

Digital competences

While the results of the past digital competences evaluations were all non-significant, this years' iteration of the Smart Sensing school yielded a significant increase in one of the competences: 'Browsing and adapting data sets in order to organize and process them' (8) = 3.464, p = .009). While there were some shifts in the other competences, none of them are significant. Figures 32 and 33 display these minimal shifts. Again, the darker the color, the better the understanding.
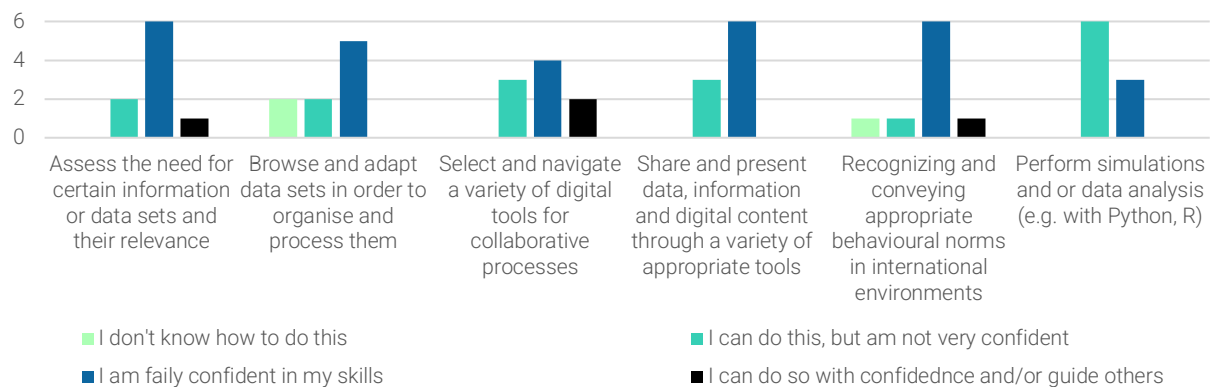
Figure 32. Digital competences before taking Smart Sensing (n=9)
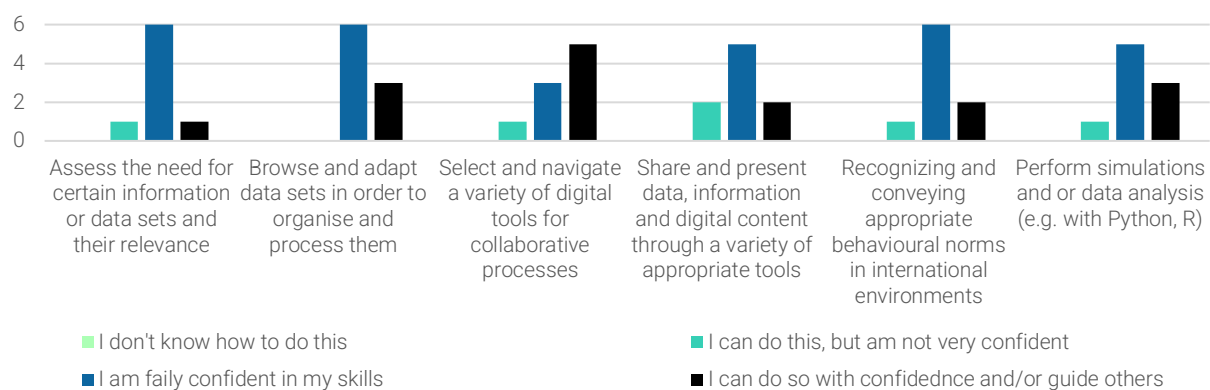
Figure 33. Digital competences after taking Smart Sensing (n=9)

The improvement on the digital competences, may attest to the success of adaptations within the workshops.

Competences (Pre / Post Comparison)

Views on competences

Before and after the course students were again also asked how important they believe the competences above are and how they personally relate to multidisciplinarity and other disciplines. As seen in the figures below and in previous evaluations, students gave high importance to the mentioned competences and multidisciplinarity already before taking the course. Therefore, none of the comparisons of the views on competences and multidisciplinarity resulted in significant paired sample t-test output. As observed in Figures 34 and 35, there are only very small changes in response patterns. (Here the legend is reversed from the35reviouss figures, and lighter colors indicate stronger agreement with statements).

■ Strongly Agree   ■ Somewhat Agree   ■ Neither Agree Nor Disagree   ■ Somewhat Disagree   ■ Strongly Disagree
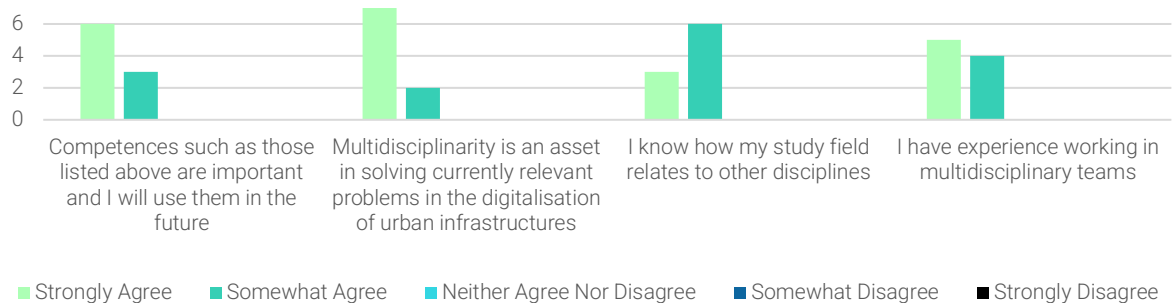
Figure 34. Views on competences before taking Smart Sensing (n=8)

■ Strongly Agree   ■ Somewhat Agree   ■ Neither Agree Nor Disagree   ■ Somewhat Disagree   ■ Strongly Disagree
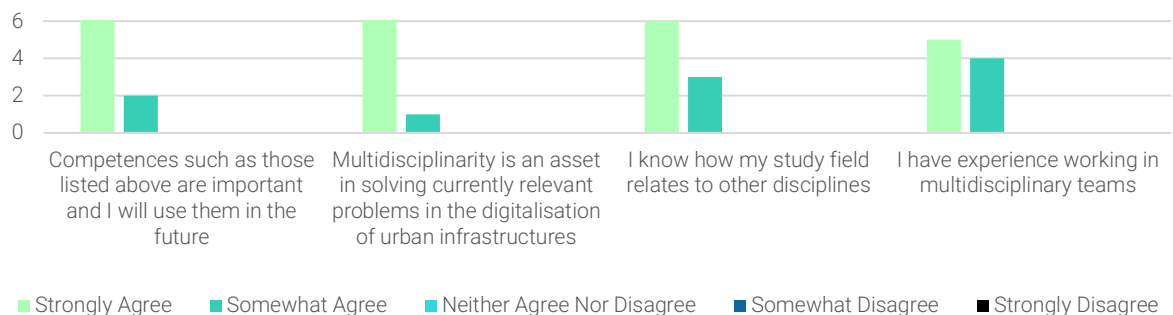
Figure 35. Views on competences after taking Smart Sensing (n=8)

General / Format

The response rate for the post-course survey for the Smart Cities school (56.5%) was again lower than that of the pre-course survey (75%), but slightly higher than last years'. Of the 13 respondents in the post-course survey, 100% agreed or strongly agree that the courses were well structured and that the pre-information about the course was sufficient. 84.6 % further indicate that the digital format of the course was well executed, while one respondent remains neutral and another strongly disagrees.

With regard to the amount of time spent for preparation, participation and follow-up, 84.6% state the effort was appropriate, one respondent evaluating it as relatively small, and one indicated it to be excessive. The net promoter score, calculated by subtracting the percentage of those unlikely to recommend the event from those who strongly agree that they will, is 76.9, with 69.2% even indicating full 10 out of 10 points on agreement. This is the best NPS yet.

The hackathon format (challenge-based learning) was rated very positively by 84.6%, indicating they really enjoyed it and wished there were more events like this. 15.4% also indicated that they were struggling a bit with group composition and output, and 23.1% additionally with the time frame. These percentages are similar to last years' responses.

In terms of group work cooperation, the Smart Cities school received similar more reviews to the Smart Sensing school, with 53.8% indicating they thought digital group work components went easily, 23.1% being indifferent and 23.1% describing it as somewhat difficult. The output of the group work during the hackathon however, performed similarly, with 69.2% saying it was 'very' or 'extremely effective' and 30.8% calling it only moderately effective.

These answers are also reflected, when looking at more detailed questions on the format. While 84.6% either agree or strongly agree that there was enough interaction and space to connect with others, only 15.4 % remain neutral. Related are the answers to the question whether students felt they connected well with others, which follow a similar pattern, as seen in Figure 36. The large majority also agreed that internationality was valuable to them.
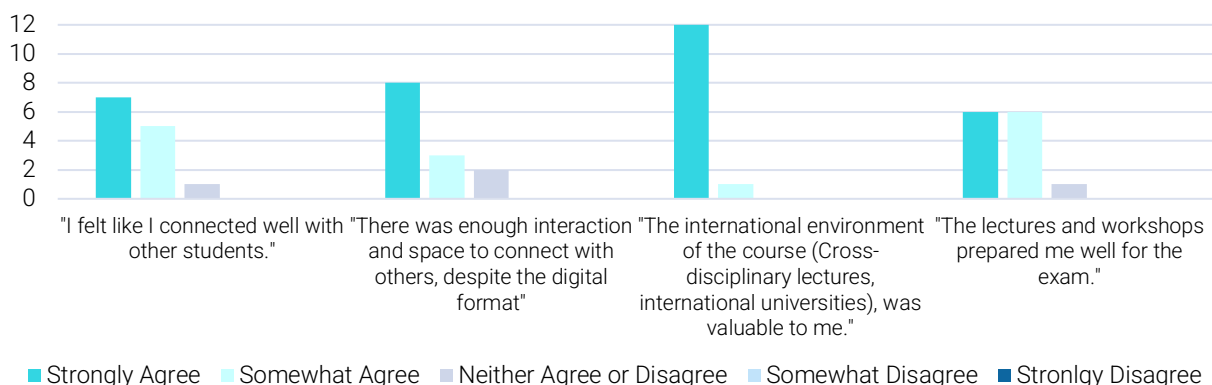

Figure 36. Format Impressions Smart Cities school (n=13)

Similarly, to responses of the Smart Sensing school, for the last question displayed in Figure 36, the feedback for the Smart Cities school also shows no negative responses this year, and only one respondent remaining neutral to the question of whether the lectures and workshops prepared them well for the exam. Again, further comments and evaluation on the workshops are found in the next section.

Workshops

General

92.3% agreed (30.8%) or strongly agreed (61.5%) that the lectures sparked their interest in the subject and found them a valuable addition to the schedule.

69.2% agreed or strongly agreed (53.8%) they could follow the workshops of the school well. 23.1% however, somewhat disagreed. These percentages are a little less convincing than those for the Smart Sensing school. Still, 100% indicated that the workshops helped them understand the lecture content better.

Journal Club
Easily understood: 100%
Troubles understanding some parts: NA
Valuable addition to the schedule: 76.9%

Design Thinking
Easily understood: 100%
Troubles understanding some parts: NA
Valuable addition to the schedule: 84.6%

Urban Stormwater Systems and Green-Blue Infrastructure - SWMM Tutorial
Easily understood: 36.3%
Troubles understanding some parts: 45.5%
Content was too difficult: 18.2%

Simulating Mobility Systems – SUMO Tutorial
Easily understood: 28.6%
Troubles understanding some parts: 64.3%
Content was too difficult: 7.1%

Additional Comments:

"For me personally i think it is my personal fault that i don't know how to use the programming environment, i think it would be better if there's an information on which app or system is going to be used so that we have some time to learn it a little bit at least."

"Maybe split up the harder workshops in two separate lessons on different days for more time"

Competences (Pre / Post Comparison)

Core intended learning outcomes (ILOs)

12 students' answers could be compared before and after. For the core ILOs regarding the knowledge on 'relevant technical problems and problem-solving approaches within the digitalization of critical urban infrastructures' and the 'synergies and interdependencies between sectors' results are very positive for the Smart Cities school. All respondents effectively increased their knowledge on all three domains from the pre-course survey (M = 2.50, SD = .674; M = 2.25, SD = .621; M = 2.25, SD = .621) to the post-course survey (M = 3.33, SD = .651; M = 3.25, SD = .622; M = 3.08, SD = .793) , with results even being statistically significant (t(11) = 2.803, p = .017; t(11) = 4.690, p = .001; t(11) = 3.458, p = .005 respectively). Figures 37 and 38 also show this quite nicely visually. Here again, the darker the color, the better the understanding.
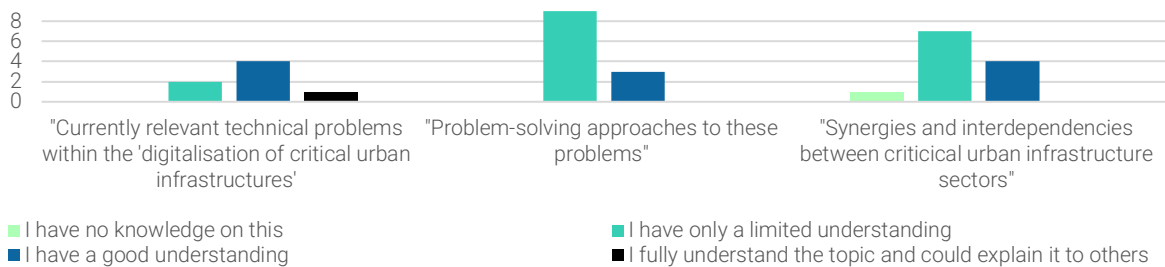
Figure 37. Core ILOs before taking Smart Cities (n=12)
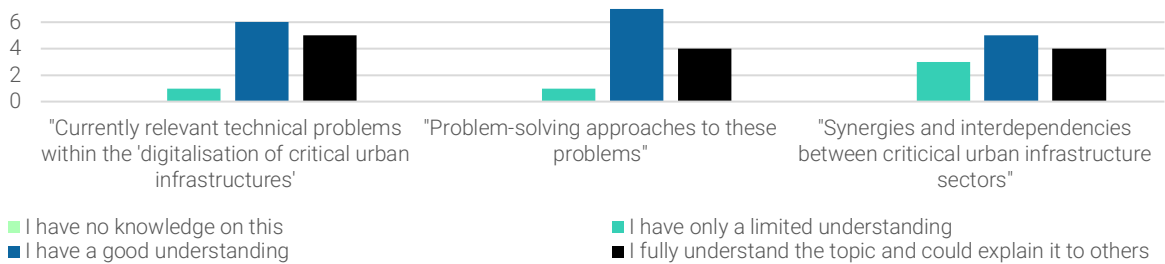
Figure 38. Core ILOs after taking Smart Cities (n=12)

23.1% indicated that they were 'somewhat' familiar with the content before taking part in the school.

Competences (Pre / Post Comparison)

Digital competences

As with the results from this years' Smart Sensing school, the Smart Cities school was also successful in yielding significant increases in the 'browse and adapt data sets' competence (t(11) = 2.569, p = .026). As observed in Figures 39 and 40, although not significant, there were some increases for most of the other digital competences as well. Here again, the darker the color, the better the understanding.
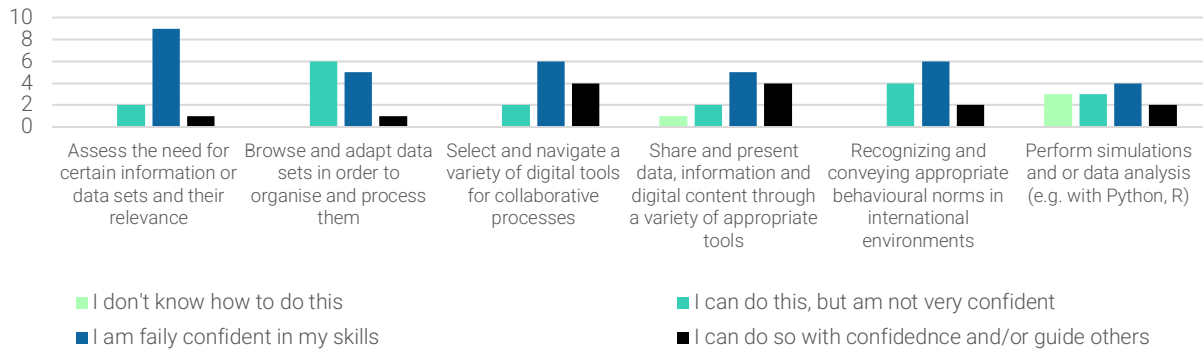

- I don't know how to do this
- I can do this, but am not very confident
- I am faily confident in my skills
- I can do so with confidednce and/or guide others

Figure 39. Digital competences before taking Smart Cities (n=9)

- I don't know how to do this
- I can do this, but am not very confident
- I am faily confident in my skills
- I can do so with confidednce and/or guide others
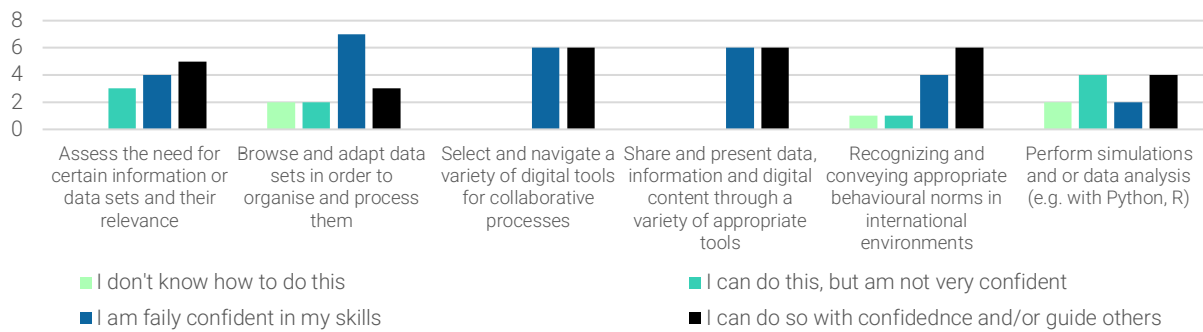
Figure 40. Digital competences after taking Smart Cities (n=9)

Competences (Pre / Post Comparison)

Views on competences

Similar to all results in this category before, students again gave high importance to the mentioned competences and multidisciplinarity already before taking the Smart Cities course. Therefore, none of the comparisons of the views on competences and multidisciplinarity resulted in significant paired sample t-test output. As observed in Figures 41 and 42 there are only very small changes in response patterns, among them slight increases for knowing how one's study field relates to other disciples and experience in multidisciplinary teams. (Here the legend is reversed again from the previous figures, and lighter colors indicate stronger agreement with statements).
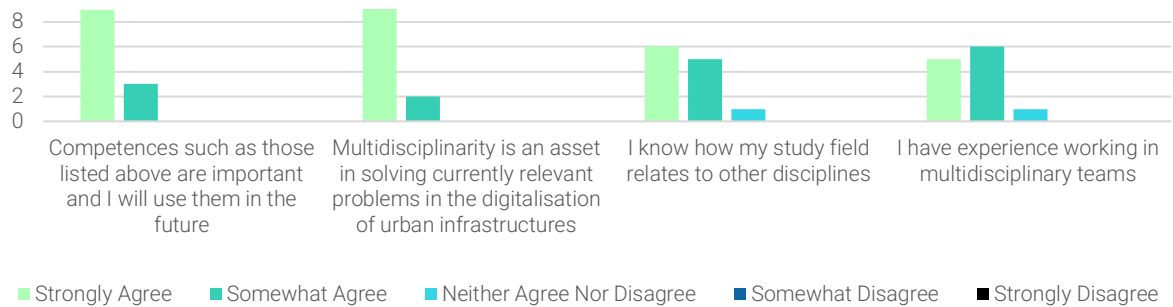
Figure 41. Views on competences before taking Smart Cities (n=12)
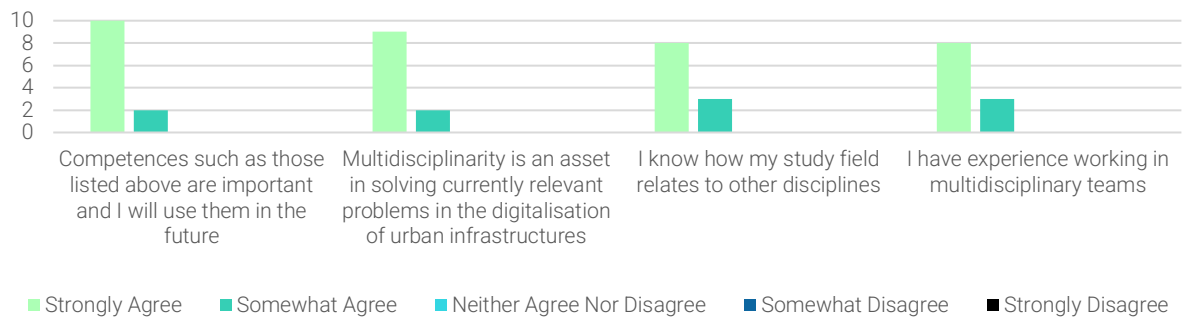
Figure 42. Views on competences after taking Smart Cities (n=11)

Communication

The most effective communication tool for advertisement across both schools was again E-mail, with 68% of respondents finding out about the schools via e-mail communication. Just as for the previous courses, none mentioned Social Media outlets.
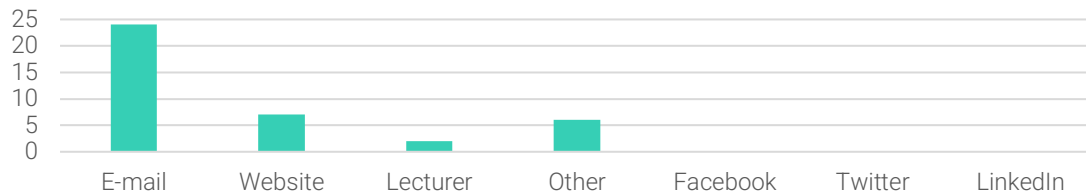

Figure 43. 'Where did you find out about this course?' (n=35)
Note: Multiple answers possible

Those in the 'other' category named friends and TUB MOSES.

Motivation

As with the previous ide3a courses, the highest-ranking motivation for participating in the schools was interest in the subject (100% of respondents). Meeting international students again ranked second (57%).
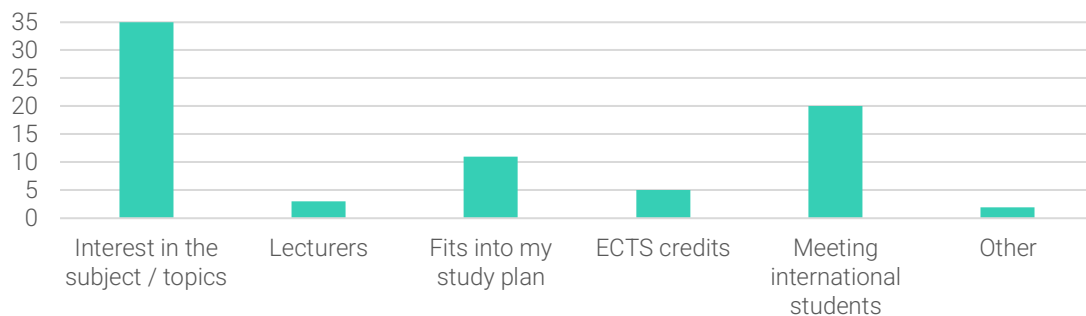

Figure 44. 'Why did you decide to participate in this course?' (n=35)
Note: Multiple answers possible

"Which parts did you find especially successful and should be retained?"
"Hackathon" (4x)
"Design Thinking"
"Tutoring session clearing questions"
"Interdisciplinary approaches, exchange between universities"
"Available mentors and organizers. Kind local people."
"Applications and technical aspects"
"The ability to come to a city, be physically present, and attend a hackathon whick lasted three days meant we had to work on a multi disciplinary team with a time constraint, which meant we had to work on our productivity outputs"
"Group work, output of the project, multidisplinary"
"The environment in the Einstein centre was lovely"
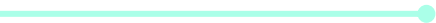"Breakout rooms online after the lessons is a top modality of work"
"Journal club was really nice. The offline Hackathon was an amazing experience."
"Hackathon of course, ECDF Office, Social events like Yoga and Christmas market."
"Various backgrounds, challenging topics"

"What parts did you find bothersome and should be improved?"
"Some of the lectures unfortunately didn't catch all my attention."

"Group formation, we were all architects in our group except one and we found it extremely difficult to complete the final task."

"Digital part, bit it is understandable"

"Some lectures, but it was very dependent on the personal interest on the topic"

"Understanding the task/defining an approach within the team"

"Last minute announcements, the covid test. I didn't know that I required cash for many things, as the Mensa for example."

"Presentation from Steffen Lange was nothing else than deleting lifetime, Design Thinking as well"

"Introduce more breaks"

"I felt like a big part of the exam was based on theory to be memorized rather than our general understanding of the info. On another note, the timing of the hackathon(online lectures in nov) was very inconvenient because it clashed with several university classes. It was a struggle to balance uni with the hackathon. A better compromise might have been to have it in the weekends."

"Maybe provide a zip file with all the slides of the lessons before"

"The composition of the group members must be modified, at least one group should have one programmer!"

"Groups should've been divided to include people from all backgrounds. Asking us to chose our own groups is nice but, people choose friends over skills in that case."

"Maybe the coding related workshops could be improved."

"online lectures"

"number of lectures in relevance to actual work time"

3.2 Critical Infrastructure and Digitalization (CID) course

3.2.1 CID SoSe 2021

General / Format

The response rate for the post-course survey (22%) was much lower than that of the pre-course survey (88%), making comparison between scores difficult to generalize. Of the 8 respondents in the post-course survey, 75% agreed or strongly agree that the course was well structured and that the pre-information about the course was sufficient. 100 % further indicate that the digital format of the course was well executed, with 50% even strongly agreeing.

With regard to the amount of time spent for preparation, participation and follow-up, 62.5% state the effort was appropriate and 25% stating it was excessive, and one person even evaluating it as small. The net promoter score, calculated by subtracting the percentage of those unlikely to recommend the event from those who strongly agree that they will, is zero, although 25% are categorized as 'promoters'. The general format of weekly changing lecturers, break out discussions and additional workshops was appreciated by several comments. 75% also agree or strongly agree, that the group discussions were a valuable opportunity to them. 25% somewhat disagree.

These answers are also reflected, when looking at more detailed questions on the format. While 62.5 % still either agree (37.5%) or strongly agree (25%), that there was enough interaction and space to connect with others, 37.5 % remain neutral. Somewhat related, answers to the question whether students felt they connected well with others, as seen in figure 45, are worth of improvement.
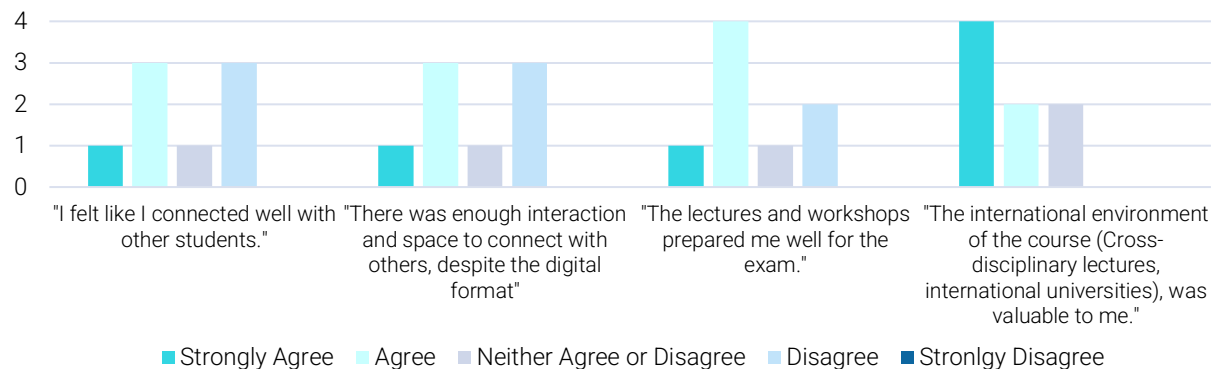

Figure 45. Format Impressions CID course (n=8)

Similarly, for the last two questions displayed in Figure 45, although trending toward positive feedback, there is still room for improvement, with 37.5% not agreeing that the lectures and Workshops prepared them well for the challenges. This was also elaborated on further in some comments, where students suggested to have the information on the exam available earlier to better be able to plan their time. Further comments and evaluation on the workshops are found in the next section. Nonetheless, 87.5 % agreed (50%) or strongly agreed (37.5%) that the lectures sparked their interest in the subject and found them a valuable addition to the schedule.

Workshop 1 - With simulations for sustainable urban stormwater management

Overall, the feedback on the two workshops during CID was not too positive, half of the students who gave feedback, could not follow the workshop well, and only 46.7% somewhat agreed they could. There were a lot of struggles with the installation and understanding them, which was improved until the second workshop, by allocating more time for debugging and giving less tasks overall.
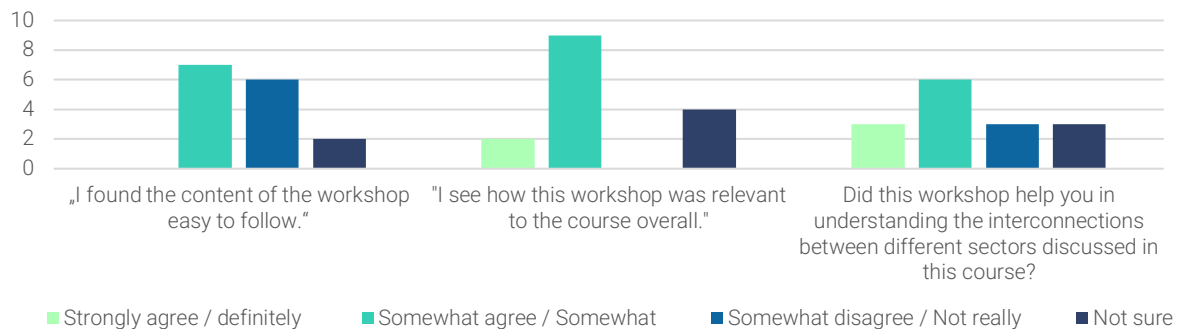

Figure 46. Feedback on Workshop 1 format (n=15)

The responses on whether the workshop seemed relevant to the students, could also have been better, given that 26% of respondents were unsure and 60% only somewhat agreed.
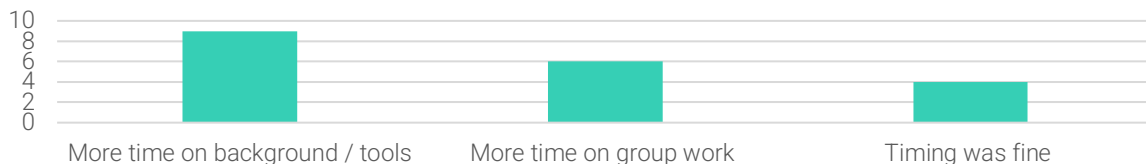

Figure 47. 'What do you think of the timing allocated to the workshop components?' (n=15)

As shown in figure 47, only 26.5% were happy with the timing, with the majority asking for more explanation on the tools and some also for more time on the group work component. Both aspects were considered during the second workshop, which is evaluated below.

Additional Comments:
"In the future it would be great if you could provide tutorials for everybody and if possible system independent software."

"We need more time to understand the working of the software before using it."

„It would be great if the tools were prepared a bit better because my team spent valuable time for debugging. All of us apart from 1 person had issues with the paths on Windows. Other than that, great work :-)"

Workshop 2 Avoiding Hazardous Environments via V2X

Although the response rate for this workshop was lower, their feedback in percentages was a bit more positive, with 66.67% agreeing that they were able to follow well. Responses related to the workshops overall relevance were somewhat the same to those of the first workshop.
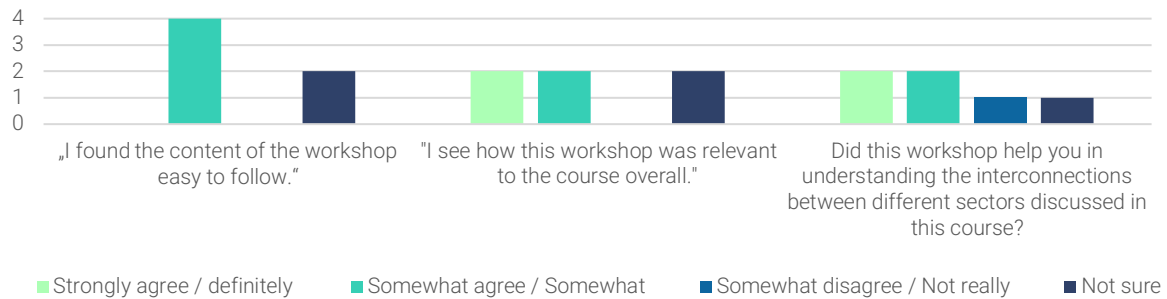

Figure 48. Feedback on Workshop 2 format (n=6)

As mentioned, feedback from the first workshop was considered during the planning of the second, but still almost all respondents indicated they wanted more time spent on tool background.
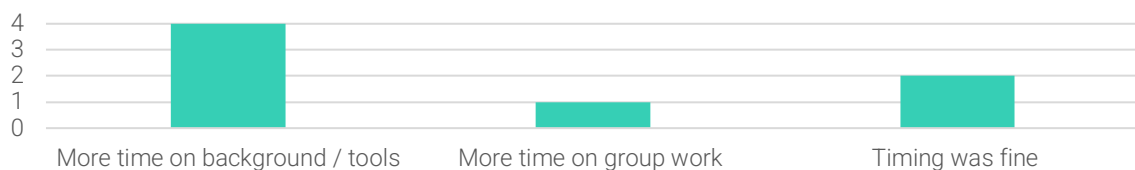

Figure 49. 'What do you think of the timing allocated to the workshop components?' (n=6)

Additional Comments:
„The workshop was easier to follow than the first one, but the study goal of both workshops weren't clear enough. Is it just to get an overview of two applications from the faculty? Do you use it for certain research projects?"

„In the course description it is also said for the report: "the final question for the report will be shared in due time, shortly after the start of the course". Maybe this would have helped us to already ask for more specific questions in the workshop for the preparation of our report. In general, I would have liked the workshops to be a bit earlier in the semester + giving the report questions earlier as well so we would have more time to write the report because getting three assignments in the last month in one's semester is quite tight. Thank you!"

Core intended learning outcomes (ILOs)

Only 7 students' answers could be compared before and after. For the core ILOs regarding the knowledge on 'relevant technical problems and problem-solving approaches within the digitalization of critical urban infrastructures' and the 'synergies and interdependencies between sectors' results are very positive. All respondents effectively increased their knowledge on all three domains from the pre-course survey (M = 3.14, SD = .38; M = 2.86, SD = .69; M = 3.0, SD = .82) to the post-course survey (M = 1.57, SD = .53; M = 1.71, SD = .49; M = 1.29, SD = .49) , with results even being statistically significant (t(6) = 7.8, p = .000; t(6) = 4.4, p = .005; t(6) = 6.0, p = .001 respectively). Figures 50 and 51 also show this quite nicely visually. The darker the color, the better the understanding.
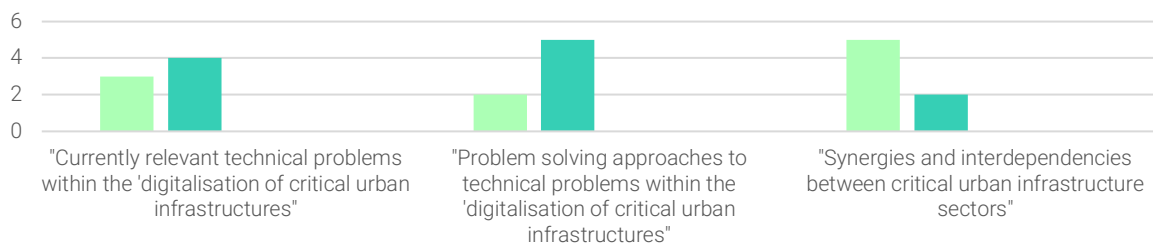

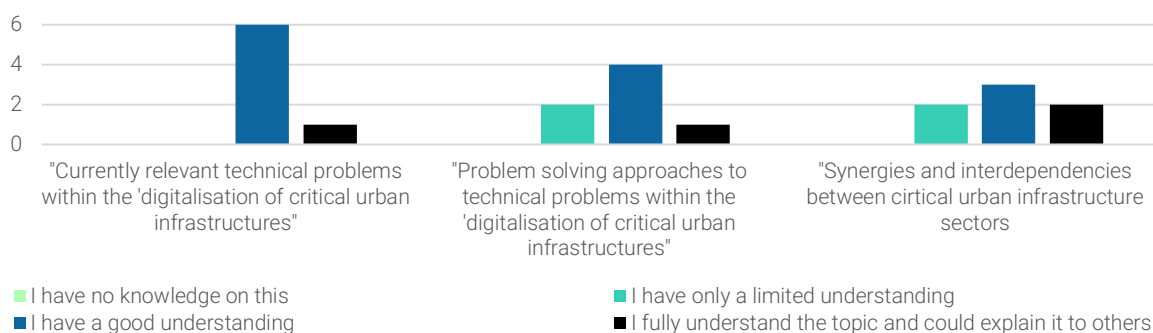*Figure 50.* Core ILOs before taking CID (n=7)

Figure 51. Core ILOs after taking CID (n=7)

87.5% of students also indicated that they were not familiar with the content of the course before taking part in it, further strengthening the case for the effectivity of the CID course.

These are the first pre- and post-evaluation results we received for ide3a, and it will be interesting to compare the evaluation of the Winter Semester 2021/2022 schools with these. Ideally all competence related questions would show these kinds of results.

Digital competences

As for the digital competences that ide3a aims to convey, results are a bit less exciting. Although there are slight increases in the knowledge for some competences increased (such as the first two in Figures 52 and 53), none of the competences results are not statistically significant in a paired sample t-test. Again, the darker the color, the better the understanding.
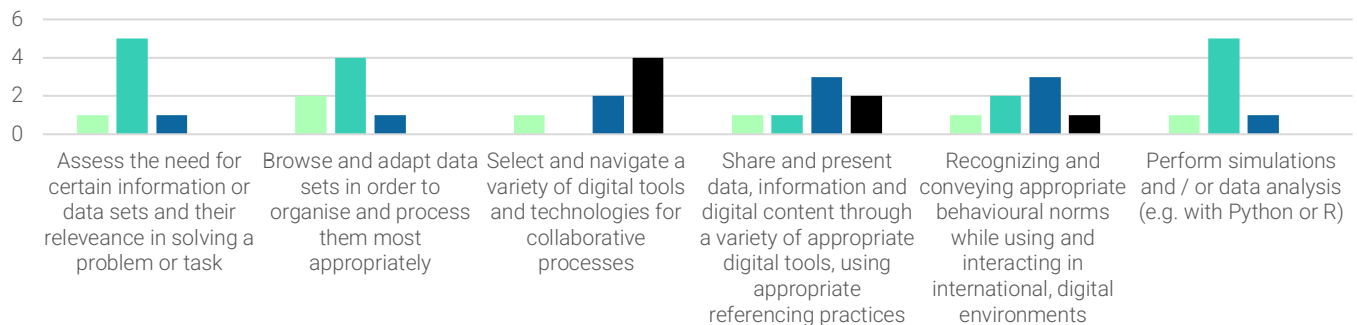

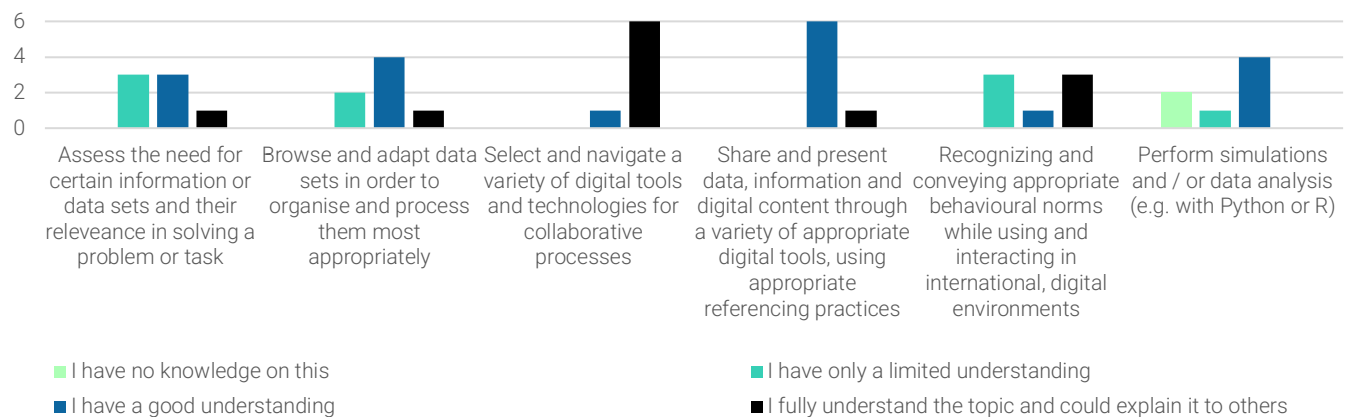*Figure 52.* Digital competences before taking CID (n=7)

Figure 53. Digital competences after taking CID (n=7)

Explanations for this may be reflected by the poor feedback on the workshops and given the fact that only two workshops were part of this semester long course. Digital competences seem are not conveyed during lectures alone, it seems. Comparison of results with the schools will give more insights on this.

Views on competences

Students were also asked before and after the course how important they believe the competences above are and how they relate to multidisciplinary and other disciplines. Interestingly enough, students gave high importance to these competences and multidisciplinarity already before taking the course. Therefore, none of the views on competences and multidisciplinarity resulted in significant paired sample t-test output. As observed in Figures 54 and 55, there almost isn't any difference in replies at all. (Here the legend is reversed from the previous figures, and lighter colors indicate stronger agreement with statements).
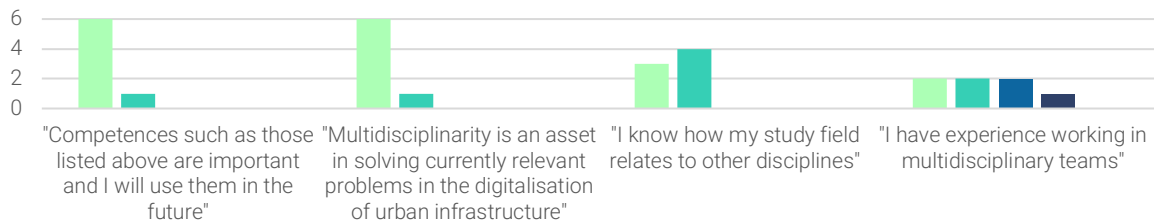

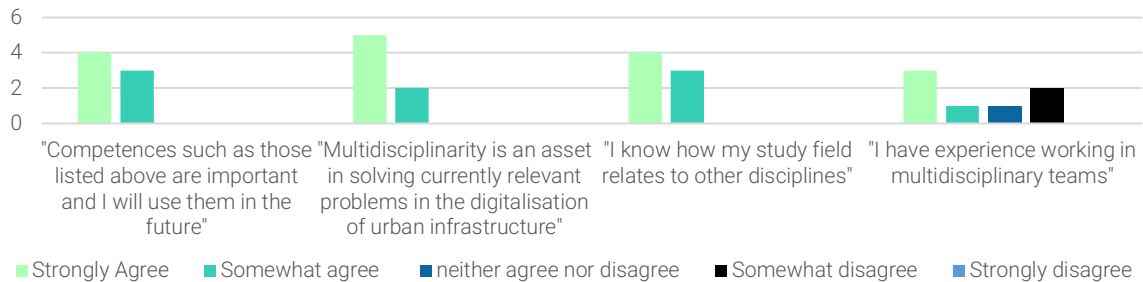*Figure 54.* Views on competences before taking CID (n=7)

Figure 55. Views on competences after taking CID

Figures 54 and 55 only show the comparison between those 7 students who filled in both surveys, the response pattern in all 32 respondents of the pre-survey looks similar. 93.8% agreed or strongly agreed that the above-mentioned digital competences are important, 90.63% agreed or strongly agreed that multidisciplinarity is an asset, 90.63% already knew how their field related to other disciplines (although 50% only somewhat agreed), and 62.5% indicated they already had experience working in multidisciplinary teams. The means were also similar with the total pre-survey respondents resulting in $M = 1.50$, $SD = .71$; $M = 1.47$, $SD = .66$; $M = 1.72$, $SD = .72$; and $M = 2.31$, $SD = 1.07$ respectively and the smaller sample post-survey respondents $M = 1.50$, $SD = .50$; $M = 1.38$, $SD = .48$; $M = 1.63$, $SD = .70$; $M = 2.25$, $SD = 1.44$.

These figures are an indication that students who are interested in the CID course (and possibly ide3a courses in general), already have a high appreciation for multidisciplinary problem solving and digitalization.

Communication
The most effective communication tool for advertisement of the CID course was E-mail, with 51.52% of respondents finding out about the CID course via e-mail communication. Closely followed by Lecturers informing them (21%). Interestingly none mentioned Social Media outlets, so perhaps the current communication strategy should be adjusted accordingly.
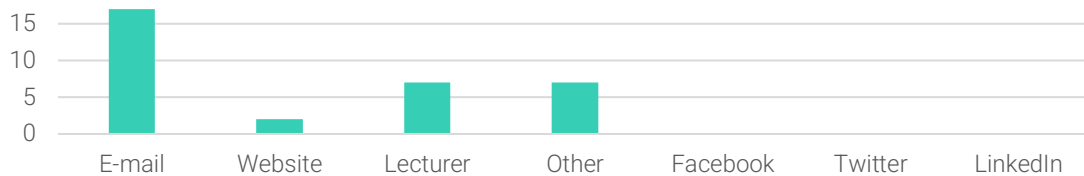

Figure 56. 'Where did you find out about CID?' (n=32)
Note: Multiple answers possible

Those in the 'other' category named friends, telegram groups and the MTS of TUB.

Motivation
As with the previous ide3a courses, the highest-ranking motivation for participating in the CID course was interest in the subject (90% of respondents). Meeting international students ranked second (50%).
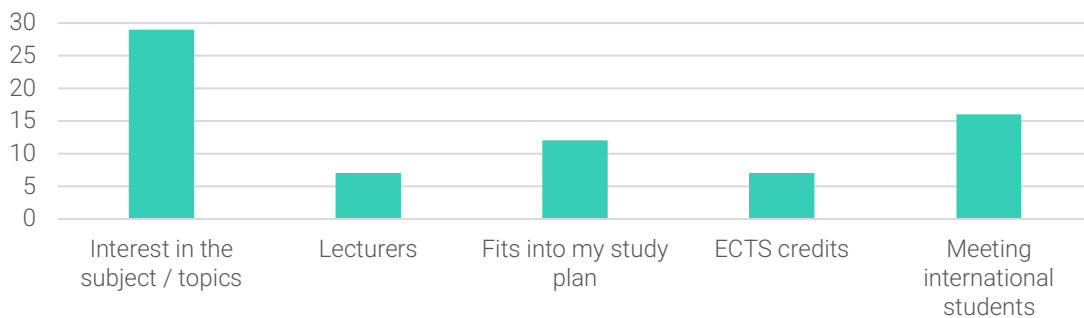

Figure 57. 'What do you think of the timing allocated to the workshop components?' (n=32)
Note: Multiple answers possible

3.2.2 SoSe 2021 Lessons learned...

Overall, the CID course seemed well received. Especially the positive feedback on the discussion group format indicates that this can be repeated next year.

One major suggestion, which also aligns with the initial goal of following constructive alignment in the course's design, would be to make the exam assignment available at the beginning of the course. This will allow students to plan their time accordingly, understand the relevance of workshops and lectures better and ask questions throughout the course that enhance their understanding of the task as well.

If workshops are to be retained during this lecture series course, they should be curated in a way that makes their purpose clear and allows students to understand and navigate the applicable software easily without much necessary prior experience. Alternatively, an additional tutorial on just the tools that explain their background and functions better is also an idea.

As the evaluation showed, digital competences were not as effectively conveyed as the core intended learning outcomes. With the above suggestions on improving the workshops, this could be corrected for, but the possibility remains that in a lecture series style course, the focus lies more on knowledge conveyance rather than on skills. Comparison of the results with the evaluation of the second iteration of schools will give more insights on this.

Notes on Evaluation

Even though the prospect of having first comprehensive evaluation results is great for the project overall, it remains unfortunate that only 8 people filled in the post-course survey. During future evaluations, answering the post-course survey should be incentivised or monitored somehow to ensure that we are able to gather more representative results.

Lastly, even though incorporating the pre-course survey in the ice breaker session resulted in a higher response rate, performance bias cannot be ruled out, meaning that students may have unconsciously exaggerated in their responses of 'current knowledge' to show that they are already quite knowledgeable, which could be an alternative explanation of the insignificant results on digital competences and the views on them. As mentioned above, improving the course further, as well as increasing sample size will give more insights during the second iteration.

3.2.3 CID SoSe 2022

General / Format

The response rate for the post-course survey (29%) was much lower than that of the pre-course survey (65%), making comparison between scores difficult to generalize. Of the 7 respondents in the post-course survey, 85.7% agreed or strongly agreed that the course was well structured and that the pre-information about the course was sufficient. 85.7 % further indicate that the digital format of the course was well executed, with 57.1% even strongly agreeing. Lastly, 85.7 % agreed (57.1%) or strongly agreed (28.6%) that the lectures sparked their interest in the subject and found them valuable additions to the schedule.

Regarding the amount of time spent for preparation, participation and follow-up, 85.7% state the effort was appropriate and one person (14.3%) even evaluated it as small. 100% also agree or strongly agree, that the group discussions were a valuable opportunity to them. There were however some critical comments on the format of these discussions in the free text space (see pg. 14).

The net promoter score, calculated by subtracting the percentage of those unlikely to recommend the event from those who strongly agree that they will, is 29 (good), with 29% categorized as 'promoters', and 71% 'passive'.

Regarding the interaction among students, feedback is moderately positive, with still some room for improvement. While 85.7 % still either agree (71.4%) or strongly agree (14.3%), that there was enough interaction and space to connect with others, 14.3% remain neutral. Responses to the question whether students felt they connected well with others, are similar as displayed in the first question in figure 58.
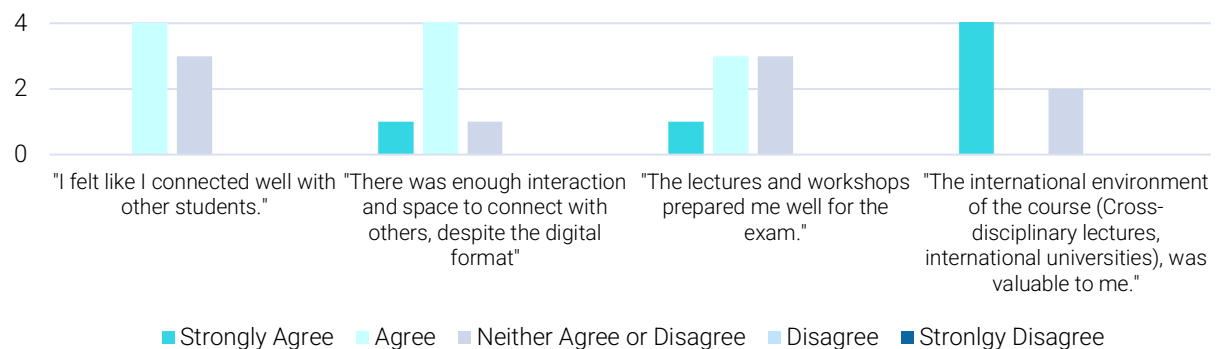

Figure 58. Format Impressions CID course (n=7)

Similarly, for the last two questions displayed in Figure 58, although trending toward positive feedback, there remains room for improvement. Unlike last year though, there was no disagreement across these questions, suggesting that implemented improvements were effective.

General

Overall, feedback on both workshops differed quite a bit from last year. Workshop 1 was evaluated much more positively than last year and more positively than Workshop 2. Workshop 2 performed slightly worse in comparison to last year. Generally, respondents indicated that they would have still liked more group work components and that the purpose of the workshops in explaining lecture content could still be improved, as indicated below.

Figure 59. General Feedback on Workshops (n=6)

Workshop 1 - With simulations for sustainable urban stormwater management

Workshop 1 drastically improved in reducing 'disagreement' responses. Since this workshop included the field trip and the only 'presence'-component of the course, engagement generally might have been a lot higher. Both in comparison to last year and Workshop 2. In the comments students especially point out their appreciation for the field trip and suggest applying the format across sectors.
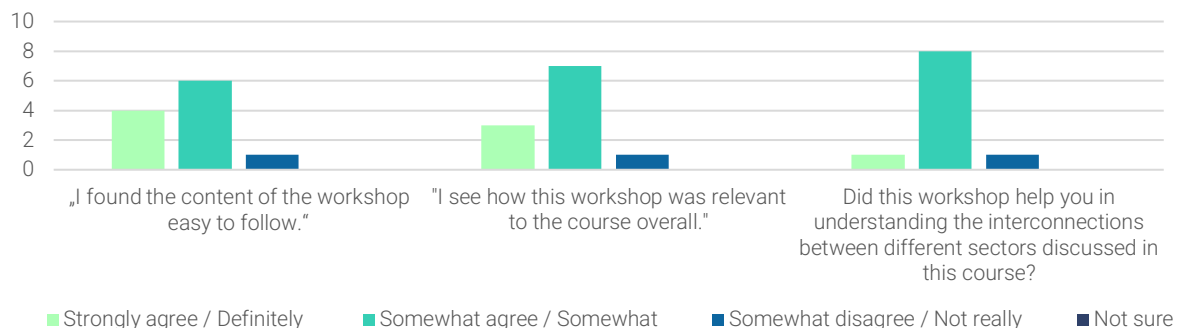

Figure 60. Feedback on Workshop 1 format (n=11)

Additional Comments:

"The first workshop and especially the excursion was very interesting! It helped relating the content of the previous lectures to some physical structures and have a better understanding of the Problems/Solutions"

"The workshops [were successful]. Especially the first one, because of the different activities and in person nature."

"I really liked the workshops, most interesting was the field trip, if something like this could be applied to more critical sectors, would be interesting."

"The workshops and the guest lectures [were successful], also the visit to the facilities."

Workshop 2 Avoiding Hazardous Environments via V2X

The response rate for this workshop was slightly lower, and most respondents indicated that they could not follow the workshop contents very well. Still, respondents could see the workshops' overall relevance to the course.
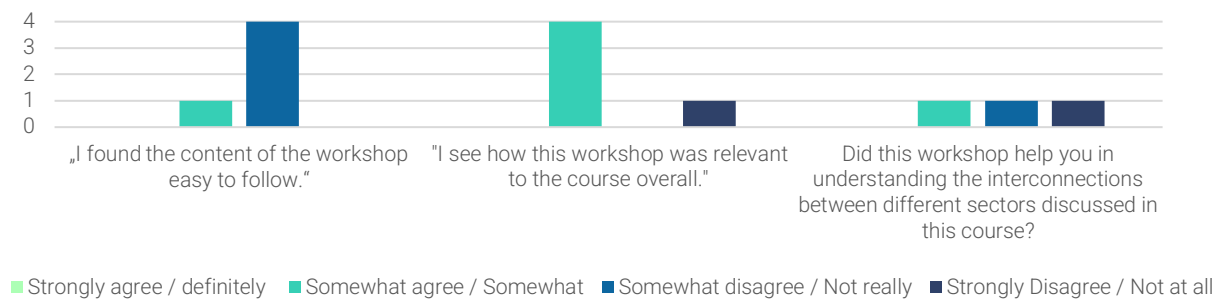

Figure 61. Feedback on Workshop 2 format (n=5)

Unfortunately, there were no further comments suggesting improvements in detail.

Core intended learning outcomes (ILOs)

Only 5 students' answers could be compared before and after. For the core ILOs regarding the knowledge on 'relevant technical problems and problem-solving approaches within the digitalization of critical urban infrastructures' and the 'synergies and interdependencies between sectors' results are again very positive. All respondents effectively increased their knowledge on all three domains from the pre-course survey (M = 2.00, SD = .71; M = 2.20, SD = .82; M = 1.80, SD = .45) to the post-course survey (M = 3.40, SD = .55; M = 3.60, SD = .55; M = 3.20, SD = .45) , with results even being statistically significant (t(4) = 3.5, p = .025; t(4) = 3.5, p = .025; t(4) = 3.5, p = .025 respectively). Figures 62 and 63 also show this quite nicely visually. The darker the color, the better the understanding.
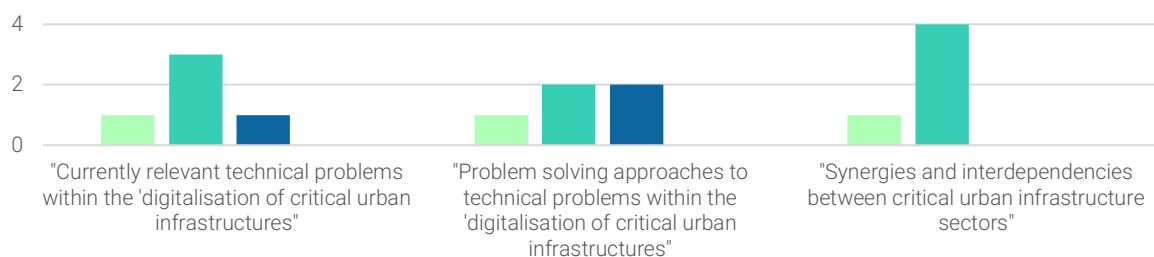

Figure 62. Core ILOs before taking CID (n=5)

■ I have no knowledge on this   ■ I have only a limited understanding
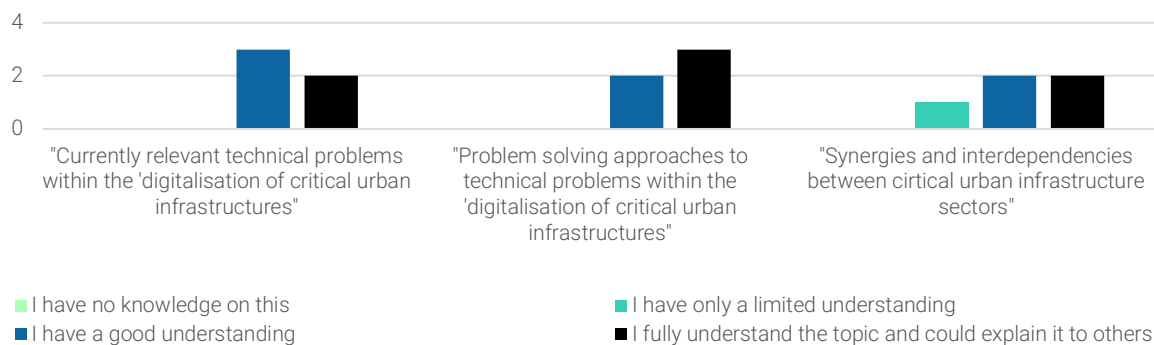■ I have a good understanding   ■ I fully understand the topic and could explain it to others

Figure 63. Core ILOs after taking CID (n=5)

Interestingly, 71.4% of students indicated that they were already familiar with some of the content of the course before taking part in it. Relying on the low response rate of the post-survey might therefore be biasing the actual effect.

Digital competences

Similarly, to the schools and the previous CID course iteration, results for the digital competences do not show any significant increases before and after taking the course. For some competences there even seems to have been a negative effect, possibly a reappraisal (such as the first two in Figures 64 and 65). None of the competences results are statistically significant in a paired sample t-test. Again, the darker the color, the better the understanding.
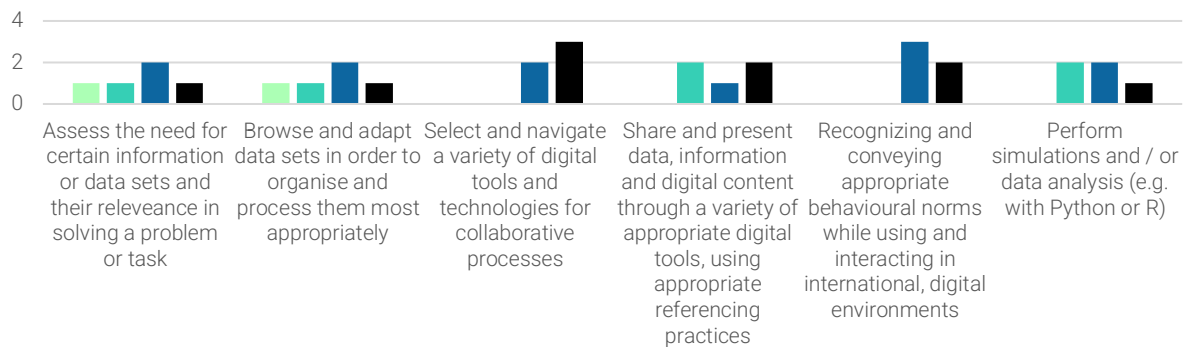

Figure 64. Digital competences before taking CID (n=5)

■ I have no knowledge on this   ■ I have only a limited understanding
■ I have a good understanding   ■ I fully understand the topic and could explain it to others
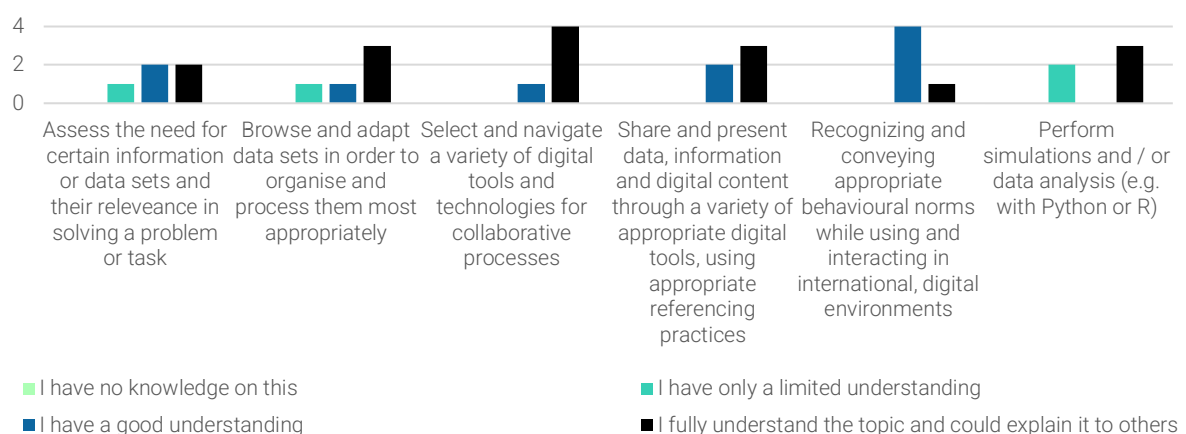
Figure 65. Digital competences after taking CID (n=5)

Students generally already seem quite confident in the evaluated competences, which could offer one angle of explanation. Additionally, they may have not been conveyed or referenced to throughout the course and may therefore seem detached from the course upon evaluation.

Views on competences

Likewise, to digital competences, students again gave high importance to these competences and multidisciplinarity already before taking the course. Therefore, none of the views on competences and multidisciplinarity resulted in significant paired sample t-test output. As observed in Figures 66 and 67, there almost isn't any difference in replies at all. (Here the legend is reversed from the previous figures, and lighter colors indicate stronger agreement with statements).
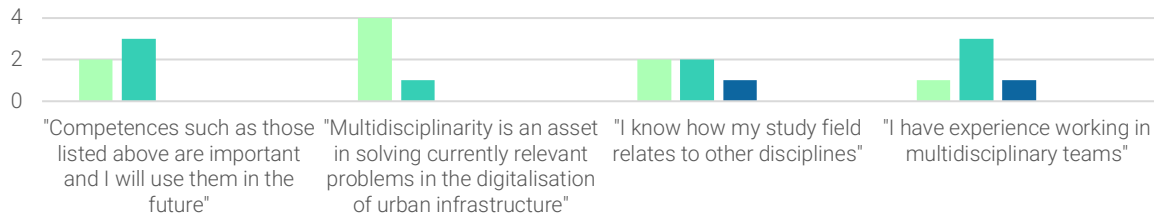

Figure 66. Views on competences before taking CID (n=5)

■ Strongly Agree ■ Somewhat agree ■ Neither agree nor disagree ■ Somewhat disagree ■ Strongly disagree

Figure 67. Views on competences after taking CID (n=5)

Figures 66 and 67, only show the comparison between those 5 students who filled in both surveys, but the response pattern in all 29 respondents of the pre-survey looks similar. 93.1% agreed or strongly agreed that the above-mentioned digital competences are important, 96.6% agreed or strongly agreed that multidisciplinarity is an asset, 82.8% already knew how their field related to other disciplines (although 55.2% only somewhat agreed), and 69% indicated they already had experience working in multidisciplinary teams. These percentages are comparable to the pre-survey responses of the 2021 CID course, hinting at a general trend in the student population.

Communication

The most effective communication tool for advertisement of the CID course was the MTS portal along with E-mail and Lecturers promotion of the course. Still, none mentioned social media outlets. Those in the 'other' category of figure 68 all named friends the MTS of TUB.
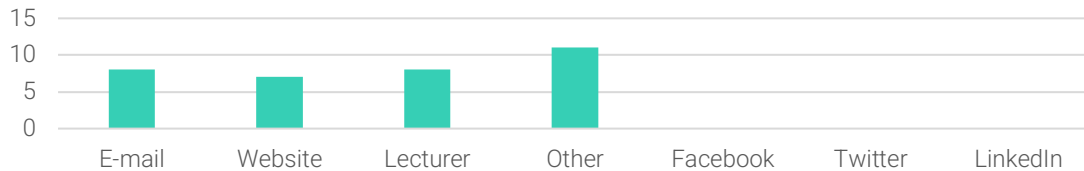

Figure 68. 'Where did you find out about CID?' (n=29)
Note: Multiple answers possible

Motivation

Again, as with the previous ide3a courses, the highest-ranking motivation for participating in the CID course was interest in the subject (100% of respondents). This iteration, alignment with students' study plan ranked second (44%).
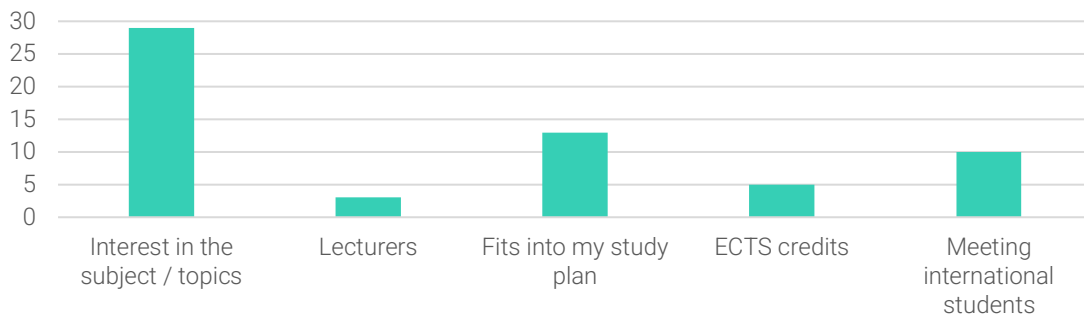

Figure 69. 'What do you think of the timing allocated to the workshop components?' (n=29)
Note: Multiple answers possible

Some students also mentioned 'the field trip', multidisciplinary setting and blended learning.

3.2.4 SoSe 2022 Lessons learned…

Overall, the CID course seemed well received again this year. Although there were some critical comments on the format of the group discussions, the format itself seemed to have been appreciated again.

Acting on some suggestions from last year, assignments were adjusted this year (removing the group presentation) and made available earlier, to allow students to more independently allocate their time. This seems to have improved feedback on format and exam preparation.

The complimentary presence elements in the first workshop seemingly yielded better reviews of this workshop in comparison to last year. Especially contrasting this feedback with that of the second workshop, which was held online, suggests that especially for the more practical components of the course, presence formats may outweigh virtual. The field trip was also much appreciated, with comments suggesting to also expand them to other sectors.

As with previous evaluations, digital competences were not as effectively conveyed as the core intended learning outcomes. There appears to be an overall tendency for students to already possess high levels of confidence in their digital competences at the beginning of the courses. Pooling the responses of students across courses will be an interesting final evaluation and might explain why any improvements in these skills may only be marginal.

Notes on Evaluation
Just as in the previous evaluations, performance bias especially during the pre-survey cannot be ruled out, meaning that students may have unconsciously exaggerated in their responses of 'current knowledge' as a perceived pressure to prove themselves in the beginning of a new course. It is unfortunate that increasing the post-course sample remains difficult.

Chapter 4: Lessons learned

This chapter aims to summarize the lessons learned across the project semesters and highlight formats that worked well. Some suggestions for further experimentation based on our results are also made.

To begin with, it can certainly be said that the overall goal of the ide3a project to implement the topic of "Critical Infrastructure & Digitalisation" in traditional study programs and "build methodological knowledge and digital competencies through the development of digital teaching and learning scenarios" has been achieved successfully. Along the journey to achieving this goal, multiple lessons were learned, and feedback continuously integrated. The lessons learned are presented here in three categories: student characteristics, organizational and didactic learnings.

Student characteristics

The group of students participating in all ide3a courses was a very diverse and intrinsically motivated one. The main reason for participation across all courses was always the interest in the topic and meeting international students, rather than gaining credits. The topic of digitalization of critical urban infrastructure therefore seems to be highly relevant for students, even across different study backgrounds. Interest in digitalization may, of course, also lie in the wide-spread every-day interaction with technology. It was therefore also somewhat unsurprising that students already showed high levels of confidence in and importance of applied digital competences before taking the course.

Students showed
- a high level of intrinsic motivation as reasons for participating
- great appreciation of the interdisciplinarity and internationality of the courses
- a gain in or expansion on digital competences following ide3a courses
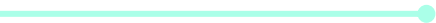- generally, already quite high levels of confidence in applied digital competences

Organizational learnings

From an organisational perspective, there were learnings every year that made the subsequent year run more smoothly, which are not necessarily generalizable. Some insights that could be interesting when considering the organization of a hackathon in educational settings may be:
- limit participation to (partner) university students (rather than opening the hackathon up to the general public)
- the hackathon format should remain within the course structure, rather than be promoted as an 'event'
- in case of a hybrid-format avoid entirely remote groups, these will be less efficient than hybrid groups
- when working with diverse study backgrounds, ensure an equal and fair distribution of skills per team
- adapt the time frame of the event to the complexity of your challenges (although time will always be restricted and 'too short')
- introduction sessions before and during the hackathon to ensure knowledge of the challenges and available data/tools are very useful

Didactic learnings

Within the ide3a project, we explored fully virtual and blended formats, as well as some asynchronous elements and challenge-based learning. Overall, it can be said that challenge-

based and traditional formats perform comparatively well in hybrid settings. In both cases however, especially the more traditional elements of 'front-based' teaching, it can't be understated how important engagement and interaction with students are. We experimented with shorter lectures and additional discussion formats, as well as crowd-questioning tools and chat platforms (such as slack), which all proved to be effective tools. These can still be taken further though and it remains to be seen which levels of communication and digitalization therefore are optimal in educational settings.

As for designing challenge-based learning courses, the major lessons are:
- start with a clearly defined "challenge-based learning" didactic framework and ILOs
- constructive alignment appears to be especially important for challenge-based learning, therefore make sure that the schedule aligns with the exam (format and challenges) and the ILOs
- include more opportunities for interaction and teambuilding in the schedule, especially in hybrid settings
- possibly include the opportunity for real-life applicability and networking with partners

An additional suggestion, which also aligns with the goal of following constructive alignment in the course's design, would be to make the exam assignment available at the beginning of the course. This will allow students to plan their time accordingly, understand the relevance of workshops and lectures better and ask questions throughout the course that enhance their understanding of the task as well.

As mentioned above, the importance of interaction and engagement, especially in hybrid settings should not be underestimated. Two formats that proved successful for this purpose in the ide3a project are the following:
- 45min lectures and 45min discussion/Q&A format
- Presence-elements surrounding workshops (field-trips, workshops, hackathon)

When incorporating workshops for more practical skills in blended courses, it seems effective to hold these in person. Within the ide3a project, we received better feedback on the workshops when they were conducted in person. Where possible, site-visits can additionally serve illustrative purposes and act as social bonding activities for further digital teaching.

Overall, the blended formats chosen within the ide3a project could successfully foster digital competences and methodological knowledge on the topic of 'digitalization of critical infrastructure'. To further experiment with the most effective levels of digital communication and education, future courses could expand on the use of asynchronous teaching material and synchronous (possibly in-presence) discussion and workshop formats.