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COMPETENCE RUBRIC

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Urban Science
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Urban Science Competence Rubric

The competence rubric represents a general tool that can be used for measuring progress in medium- or long-term processes or through the whole Urban Science learning journey. The rubric was designed as a pre and post intervention tool, with which teachers can evaluate their students' progress. However, the tool can also be transformed (or adapted) to specific sets of learning modules. This is specifically valuable if the time frame of the learning modules exceeds at least three lessons and is preferable completed over the course of two weeks or more (according to related literature, shorter interventions might not have measurable effects). Effects measured by any pre and post intervention tool might be influenced by many other factors including school culture (e.g. level of student autonomy, democratic processes including open dialogues, support for evidence-based decisions, teachers' roles, students' involvement in and responsibility for their own learning etc.), previous experiences with teaching-learning methods, teachers' didactical repertoire and former experience with inquiry-based learning etc. Generally, the less exposed students were to open instructions and inquiry-based work, the bigger the first measured impact is and vice versa. In other cases, lack of supportive didactical (or local) learning environment, hesitation, frustration or anxiety of teachers, irregular and brief exposure to new forms of learning may hinder the successful introduction of the learning modules, or may generate frustration, lack of understanding, anxiety or refusal in students, which result in no measurable progression.

The competence rubric was prepared with a thorough examination and revision of the Urban Science Competence Framework described in Intellectual Output 2. The competence elements were studied and re-clustered (see Annex 1) resulting in a new framework (see Annex 2).

The adaptation and use of the competence rubric are recommended via the following procedure:

1. Before the adaptation, please consider the proposed intervention:

- Is it a set of modules that you are working within a specific group of students?
- Is it only one module that they will use in this specific group?
- Will students be exposed to other Urban Science activities?

2. Based on this, a decision is needed whether to keep the general rubric to cover all competences, or to modify the rubric (as in Annex 3). For this, it is recommended to examine the learning module (aims, learning outcomes) to see whether the competences are all applicable in that designed learning environment. The adaptation of the rubric is not applicable for learning modules that are being adapted or modified (in an action research cycle, for example), especially if teaching-learning aims might change during the process.

3. At this point, please revise the language.

- Does it correspond to terms in your curricula?
- Is it relevant for the student group to be assessed?

4. The teacher assesses all students in the group before they start working with the Urban Science learning module(s). It is possible to make an online questionnaire or use an online platform. If the results of the pre and post assessment are shared with external persons including researchers, special attention should be paid to the following:

- In many countries EU (or own) data protection regulations apply, therefore teachers (or researchers) may want to give codes to students and use that when processing the data from the assessment.
- It may also be necessary in case of external involvement to have an agreement with the school and to briefly notify parents that such assessment is taking place and explain in which context the data is used and refer to the fact that it is anonymous and will not be part of the school's assessment.
- It needs to be decided and reflected on how to communicate about the assessment (if communication is needed).
- It may also be interesting to only focus on some of the competences especially if the Urban Science work is carried out in a tight time frame using only one or a few of the learning modules.

5. Design the timing of the post-intervention assessment.

6. At the end of the trial period, the teacher assesses all students in their group again using the same rubric.

7. The pre- and post-intervention results are compared. Observed changes are evaluated considering some general factors (see above).

The rubric can also be transformed to a student self-assessment tool.

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Annex 1. Merging competences – overview

The following table shows how the competences in the rubric are linked to the IO2 Framework Urban Science competences. Inquiry-based science (IBSE) competences are shown in white, sustainability competences are displayed in green and new competence areas are demonstrated in grey cells.

Competence area in rubric	Competences (elements from IO2 Urban Science key competences)					
Develop knowledge and understanding of key Urban Science issues (including understanding basic characteristics of scientific thinking and urban environment and understanding scientific theory)	1.a. Able to connect different elements within an urban environment;	1.b. Seeing how they relate to each other;	1.a. State observable features	1.b. State or use a classification system	1.c. State a relationship between variables	

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Competence area in rubric	Competences (elements from IO2 Urban Science key competences)								
Able to use scientific methods for inquiry in urban science	2.a. Identify equipment	2.b. Use equipment	2.c. Describe a standard procedure	2.d. Carry out a standard procedure					
Carry out inquiry science activities (including posing a question, developing a strategy, proposing a method, collecting and interpreting data, drawing a conclusion) in urban context	3.a. Propose a question	3.b. Plan a strategy	3.c. Evaluate risk	3.d. Collect relevant data	3.e. Present data effectively	3.f. Process data	3.g. Interpret data	3.h. State a conclusion	3.i. Evaluate a conclusion

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Competence area in rubric	Competences (elements from IO2 Urban Science key competences)					
Apply systems thinking to evaluate consequences of human activities in urban environments	1.c. Recognising that all actions are part of a system; and	1.d. Often have multiple consequences positive or negative.	2.b. To understand how human activity that exceeds ecological limits or capacity has negative effects; and	1.d. Show understanding of scientific theory		
Understand natural systems in the context of a city, using science knowledge	2.a. Understanding how natural systems work within limits and use a range of strategies to adapt, optimise and flourish;	1.d. Show understanding of scientific theory	1.a. State observable features	1.b. State or use a classification system	1.c. State a relationship between variables	
Understand the basic features of sustainable urban systems, using science knowledge	2.c. Sustainable systems balance resource use within a fixed carrying capacity.	2.b. To understand how human activity that exceeds ecological limits or capacity has negative effects	1.d. Show understanding of scientific theory	1.a. State observable features	1.b. State or use a classification system	1.c. State a relationship between variables

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Competence area in rubric	Competences (elements from IO2 Urban Science key competences)							
Understand alternative futures in urban environments, using science knowledge	3.a. Develop ideas for alternative futures	3.b. Understand alternative futures	3.c. Evaluate alternative futures	3.c. Evaluate risk	1.d. Show understanding of scientific theory	1.a. State observable features	1.b. State or use a classification system	1.c. State a relationship between variables
Identify behaviours and values that reinforce a sustainable future	4.a. Identify behaviours and values that reinforce a sustainable future; and	1.d. Show understanding of scientific theory	1.d. Show understanding of scientific theory	3.g. Interpret data	3.h. State a conclusion	3.i. Evaluate a conclusion		
Able to apply a values perspective to decision-making; integrating scientific knowledge with personal and societal values in making choices.	4.b. Able to apply a values perspective to decision-making; integrating scientific knowledge with personal and societal values in making choices.	1.d. Show understanding of scientific theory	1.d. Show understanding of scientific theory	3.g. Interpret data	3.h. State a conclusion	3.i. Evaluate a conclusion		

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Competence area in rubric	Competences (elements from IO2 Urban Science key competences)						
Apply scientific evidence to distinguish between sustainable and unsustainable actions in urban environments	5.a. Being able to distinguish between actions which improve or quality of life versus quantitative changes in material standards.	1.d. Show understanding of scientific theory	1.d. Show understanding of scientific theory	3.g. Interpret data	3.h. State a conclusion	3.i. Evaluate a conclusion	
Agency and responsibility supported by scientific thinking	3.d. Able to predict the consequences of actions today on future choices and their ability to act.	6.a. Able to take responsibility to develop and implement plans.	3.d. Collect relevant data	3.f. Process data	3.g. Interpret data	3.h. State a conclusion	3.i. Evaluate a conclusion
Evaluate success of (proposed) interventions in cities based on scientific thinking	6.b. Evaluate their success.	3.d. Collect relevant data	3.e. Present data effectively	3.f. Process data	3.g. Interpret data	3.h. State a conclusion	3.i. Evaluate a conclusion

Annex 2. The Urban Science Competence Rubric

The Urban Science competences are merged to 12 competence areas and are described at four levels.

	Competence area	Novice	Beginner	Practicing	Advanced
1	*Develop knowledge and understanding of key Urban Science issues (including understanding basic characteristics of scientific thinking and urban environment)*	Need to develop understanding of scientific thinking in the context of urban environment	Able to identify elements of scientific thinking and to identify urban challenges	Apply some elements of scientific thinking to understand challenges in an urban environment	Able to apply scientific thinking to understand challenges in an urban environment
2	*Able to use scientific methods for inquiry in urban science*	Need to learn methods of science inquiry	Need to practice methods of science inquiry in urban context	With support use scientific methods in urban context	Able to use scientific methods in urban context
3	*Carry out inquiry science activities (including posing a question, developing a strategy, proposing a method, collecting and interpreting data, drawing a conclusion) in urban context*	Need to acquire inquiry activities in urban context	With scaffolding able to complete an inquiry activity in urban context	With (some) support able to use science inquiry in urban context	Able to apply science inquiry autonomously in urban context
4	*Apply systems thinking to evaluate consequences of human activities in urban environments*	Needs to know more about consequences of human activities and cities as systems	Understands consequences of human activities in urban environments also with a systems perspective	With support apply elements of systems thinking to evaluate consequences of human activities in urban environments	Able to apply systems thinking to evaluate consequences of human activities in urban environments

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	Competence area	Novice	Beginner	Practicing	Advanced
5	*Understand natural systems in the context of a city, using science knowledge*	Need to learn more about the main characteristics of natural systems	Able to recognise some system characteristics of natural systems in the context of a city, using science knowledge	Able to understand some characteristics of natural systems in the context of a city, using science knowledge	Generally, understand natural systems in the context of a city, using science knowledge
6	*Understand the basic features of sustainable urban systems, using science knowledge*	Need to know more about the basic features of sustainable urban systems	Able to identify some basic features of sustainable urban systems, using science knowledge	Able to distinguish between sustainable and unsustainable urban systems, using science knowledge	Using science knowledge, understand the basic features of sustainable urban systems
7	*Understand alternative futures in urban environments, using science knowledge*	Need to develop time-related thinking in urban context	Able to understand the basics of forecast and predict alternative scenarios using scientific thinking	Able to develop ideas about alternative futures and with support understands them using scientific thinking	Develop ideas and understand alternative futures in urban context, based on scientific thinking
8	*Identify behaviours and values that reinforce a sustainable future*	Need to learn more about values in a sustainability context	Able to identify some behaviours and values in a sustainability context	Able to identify some behaviours and values that act towards a sustainable future	Able to distinguish between behaviours and values that act towards a sustainable and an unsustainable future

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	Competence area	Novice	Beginner	Practicing	Advanced
9	*Able to apply a values perspective to decision-making; integrating scientific knowledge with personal and societal values in making choices.*	Need to understand the role of scientific knowledge and values in decision-making	Understand the role of scientific knowledge and values in decision-making	With support apply a values-perspective in decision-making	Able to apply a values-perspective in decision-making
10	*Apply scientific evidence to distinguish between sustainable and unsustainable actions in urban environments*	Needs to know more about sustainable and unsustainable actions in urban environments	Able to understand the difference between sustainable and unsustainable actions in urban environments	In some cases, or with support, able to distinguish between a sustainable and an unsustainable action using scientific evidence	Able to distinguish between a sustainable and an unsustainable action using scientific evidence
11	*Agency and responsibility supported by scientific thinking*	Need to develop responsibility and ownership for actions	Understands evidence supporting responsibility for actions in urban environment	Need to develop agency but express responsibility for actions in urban environment	Ready to practice evidence-based responsibility for actions in urban environment
12	*Evaluate success of (proposed) interventions in cities based on scientific thinking*	Need to practice how to evaluate consequences of actions in systems such as cities	Possess skills to evaluate actions in systems	Able to apply scientific thinking to evaluate success of interventions in urban environment	Able to evaluate success of (proposed) interventions in cities based on scientific thinking

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Annex 3. Examples of transforming the competence rubric

Sounds in my city rubric

	Competence area	remark	Novice	Beginner	Practicing	Advanced
1	*Develop knowledge and understanding of NOISE*	*applicable*	Need to develop understanding of scientific thinking in the context of noise in the urban environment	Able to identify elements of scientific thinking and to identify urban challenges	Apply some elements of scientific thinking to understand challenges in an urban environment	Able to apply scientific thinking to understand challenges in an urban environment
2	*Able to use scientific methods for inquiry about noise in the city*	*applicable*	Need to learn methods of measuring and mapping noise	Need to practice methods of measuring and mapping noise in urban context	With support measure and map in urban context	Able to measure and map noise in a city
3	*Carry out inquiry science activities (including posing a question, developing a strategy, proposing a method, collecting and interpreting data, drawing a conclusion) in the noise in the city context*	*applicable*	Need to acquire inquiry activities in urban context	With scaffolding able to complete an inquiry activity about noise in the city	With (some) support able to use science inquiry about noise in the city	Able to apply science inquiry autonomously about noise in the city
4	*Apply systems thinking to evaluate consequences of human influence on noise in the city*	*applicable*	Needs to know more about consequences of human activities about noise in the city	Understands some consequences of human noise in cities	With support apply elements of systems thinking to evaluate consequences of human noise pollution in cities	Able to apply systems thinking to evaluate consequences of human noise pollution in cities

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	Competence area	remark	Novice	Beginner	Practicing	Advanced
5	*Understand natural systems in the context of a city, using science knowledge*	*not applicable in this module*	Need to learn more about the main characteristics of natural systems	Able to recognise some system characteristics of natural systems in the context of a city, using science knowledge	Able to understand some characteristics of natural systems in the context of a city, using science knowledge	Generally, understand natural systems in the context of a city, using science knowledge
6	*Understand the basic features of sustainability and noise in cities, using science knowledge*	*applicable*	Need to know more about the basic features of noise in sustainable urban systems	Able to identify some basic features of noise in sustainable urban systems, using science knowledge	Able to distinguish between sustainable and unsustainable noise in urban systems, using science knowledge	Using science knowledge, understand the basic features of sustainable noise in urban systems
7	*Understand alternative futures in urban environments, using science knowledge*	*not applicable in this module*	Need to develop time-related thinking in urban context	Able to understand the basics of forecast and predict alternative scenarios using scientific thinking	Able to develop ideas about alternative futures and with support understands them using scientific thinking	Develop ideas and understand alternative futures in urban context, based on scientific thinking
8	*Identify behaviours and values that reinforce a sustainable future in the context of noise*	*applicable*	Need to learn more about values concerning noise in a sustainability context	Able to identify some behaviours and values in a sustainability context about noises	Able to identify some behaviours and values that act towards a sustainable future in the context of noise	Able to distinguish between behaviours and values that act towards a sustainable and an unsustainable future about noise in the city

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	Competence area	remark	Novice	Beginner	Practicing	Advanced
9	*Able to apply a values perspective to decision-making about noises; integrating scientific knowledge with personal and societal values in making choices.*	applicable	Need to understand the role of scientific knowledge and values in the context of noise pollution	Understand the role of scientific knowledge and values in decision-making about noise	With support apply a values-perspective in decision-making about noise	Able to apply a values-perspective in decision-making about noise pollution or protection
10	*Apply scientific evidence to distinguish between sustainable and unsustainable actions in the noise in the city context*	applicable	Needs to know more about sustainable and unsustainable actions in urban environments	Able to understand the difference between sustainable and unsustainable actions in urban environments	In some cases, or with support, able to distinguish between a sustainable and an unsustainable action in the context of noises using scientific evidence	Able to distinguish between a sustainable and an unsustainable action in the context of noises using scientific evidence
11	*Agency and responsibility about noise in the cities supported by scientific thinking*	applicable	Need to develop responsibility and ownership for making/preventing noises	Understands evidence supporting responsibility for noises in urban environment	Need to develop agency but express responsibility for noise-related actions in urban environment	Ready to practice evidence-based responsibility for noise-related actions in urban environment
12	*Evaluate success of noise protection in their city based on scientific thinking*	applicable	Need to practice how to evaluate consequences of noise-related actions in systems such as cities	Possess skills to evaluate consequences of noise pollution in cities	Able to apply scientific thinking to evaluate success of interventions about noise in urban environment	Able to evaluate success of (proposed) interventions concerning noise in cities based on scientific thinking

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Heatwaves rubric

	Competence area	remark	Novice	Beginner	Practicing	Advanced
1	*Develop knowledge and understanding of the changes in temperature in the urban environment*	applicable	Need to develop understanding of the heat island effect	Able to identify elements of scientific thinking and to identify urban challenges	Apply some elements of scientific thinking to understand challenges in an urban environment	Able to apply scientific thinking to understand challenges in an urban environment
2	*Able to use scientific methods for inquiry about the changes in temperature and their effects in urban context*	applicable	Need to learn measuring temperature, modelling, designing and carrying out a research project	Need to practice methods in urban context	With support use scientific methods in urban context	Able to use scientific methods in urban context
3	*Carry out inquiry science activities (including posing a question, developing a strategy, proposing a method, collecting and interpreting data, drawing a conclusion) in urban context*	only partly applicable	Need to acquire inquiry activities in urban context	With scaffolding able to complete an inquiry activity in urban context	With (some) support able to use science inquiry in urban context	Able to apply science inquiry autonomously in urban context
4	*Apply systems thinking to evaluate the consequences of human activities regarding the heat island effect in urban environments*	applicable	Needs to know more about consequences of human activities concerning the rise in temperature and cities as systems	Understands consequences of human activities concerning the rise in temperature in urban environments also with a systems perspective	With support apply elements of systems thinking to evaluate consequences of human activities concerning the rise in temperature in urban environments	Able to apply systems thinking to evaluate consequences of human activities concerning the rise in temperature in urban environments

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	Competence area	remark	Novice	Beginner	Practicing	Advanced
5	*Understand natural systems of cooling and heating effects in the context of a city, using science knowledge*	applicable	Need to learn more about the main characteristics of natural cooling and heating systems	Able to recognise some system characteristics of natural cooling and heating systems in the context of a city, using science knowledge	Able to understand some characteristics of natural cooling and heating systems in the context of a city, using science knowledge	Generally, understand natural cooling and heating systems in the context of a city, using science knowledge
6	*Understand the basic features of sustainable urban solutions concerning the changes in temperature, using science knowledge*	applicable	Need to know more about the basic features of sustainable urban systems	Able to identify some basic features of sustainable urban systems, using science knowledge	Able to distinguish between sustainable and unsustainable urban systems, using science knowledge	Using science knowledge, understand the basic features of sustainable urban systems
7	*Understand alternative futures in urban environments, using science knowledge*	not applicable in this module	Need to develop time-related thinking in urban context	Able to understand the basics of forecast and predict alternative scenarios using scientific thinking	Able to develop ideas about alternative futures and with support understands them using scientific thinking	Develop ideas and understand alternative futures in urban context, based on scientific thinking
8	*Identify behaviours and values that reinforce a sustainable future concerning climate change*	applicable	Need to learn more about values in a sustainability context	Able to identify some behaviours and values in a sustainability context	Able to identify some behaviours and values that act towards a sustainable future in the context of heatwaves	Able to distinguish between behaviours and values that act towards a sustainable and an unsustainable future in the context of heatwaves

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	Competence area	remark	Novice	Beginner	Practicing	Advanced
9	*Able to apply a values perspective to decision-making about sustainable redesigning solutions; integrating scientific knowledge with personal and societal values in making choices.*	applicable	Need to understand the role of scientific knowledge and values in decision-making	Understand the role of scientific knowledge and values in decision-making	With support apply a values-perspective in decision-making about sustainable green urban environment	Able to apply a values-perspective in decision-making about sustainable green urban environment
10	*Apply scientific evidence to distinguish between sustainable and unsustainable actions and designs in urban environments*	applicable	Needs to know more about sustainable and unsustainable actions and designs in urban environments	Able to understand the difference between sustainable and unsustainable actions and designs in urban environments	In some cases, or with support, able to distinguish between a sustainable and an unsustainable actions and designs using scientific evidence	Able to distinguish between a sustainable and an unsustainable actions and designs using scientific evidence
11	*Agency and responsibility about change in temperature by scientific thinking*	applicabl*e*	Need to develop responsibility and ownership for the rising temperature and climate change	Understands evidence supporting responsibility for the rising temperature and climate change in urban environment	Need to develop agency but express responsibility for temperature rising in urban environment	Ready to practice evidence-based responsibility for temperature rising actions in urban environment
12	*Evaluate success of redesigning districts towards sustainability in cities based on scientific thinking*	applicable	Need to practice how to evaluate consequences of climate stabilizing actions in systems such as cities	Possess skills to evaluate consequences of the rise in temperature in cities	Able to apply scientific thinking to evaluate success of interventions regarding the rise in temperature in urban environment	Able to evaluate success of (proposed) interventions regarding the rising temperature in cities based on scientific thinking

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