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Smart, sustainable and attractive.

Reflections on collaboration

in projects between industry, society, academy and students

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About Viable Cities

Viable Cities is a programme for innovation enabling smart and sustainable cities. It is one of 17 Swedish strategic innovation programmes jointly funded by Vinnova, the Swedish Energy Agency and Formas. The aim of this joint national effort is to create conditions for international competitiveness and address global societal challenges. Viable Cities is coordinated by KTH.

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Summary and recommendations

The background for this brief work is the open question how universities and society (industry, cities) can increase the level of collaboration and co-creation for smart and sustainable cities involving students.

- There is already a strong interest from students to add challenge driven courses but it is quite often difficult to add them to their degree due to several reasons. The most important are lack of enough free space in the curricula and a perceived mismatch of learning outcomes in relation to program goal and degree requirements. Some courses have found their "place" in the curricula but some other are struggling to do so.

- Many teachers are interested in challenge driven courses but experience is limited. The few examples that exist are typically not harvesting the possibility with multi- and cross-disciplinarity. This is especially evident in the early project phases where industrial partners or faculty often takes the lead in problem formulation. It is also hard to scale up courses to large volumes of students.

- Collaboration between universities and industry and society involving students are today mostly based on old traditional structures and well-established contact between teachers, students' sections, and industry. It is hard to find new contacts and suitable courses. The academic system with different types of programs and degrees is not obvious to navigate. Industries and cities are also reluctant to further give away the problem formulation process to the students or even teachers and researchers. This is something required in a truly challenge driven approach.

- When recruiting top students from universities industry tend to use unstructured complex problems for the applicants to solve through case study methods. The purpose is to find the most talented and creative. Obviously, by involving industry in challenge driven courses learning this can be trained and refined much earlier in the education for the benefit of all stakeholders.

What needs to be done?

- The structure of master programs at KTH and elsewhere need to make room for multi- and cross-disciplinary courses as an alternative to more depth in the chosen subject are. Universities should also consider and dare starting new programs with alterative structures. A "market analysis" for this should be done, possible as an initiative within Viable Cities.

- Learning outcomes and examination of courses need to secure progression in the educational system. Broad teams of teachers need to be available to support students especially on master level in order to secure quality. Make clear the level of ambition when it comes to multi-, cross- or even interdisciplinary courses and state this in

learning outcomes and examination. Cross-disciplinarity requires that the students actually have acquired a discipline meaning that they should be on a similar level of progression.

- Teachers need to build a common pool of knowledge and exchange ideas and methods for different types of courses. Particular areas of interest should be quality assurance, examination methods, securing progression and various degrees of multi-disciplinarity.

- Some sort of match-making service/activity should take place preferable in April (for fall courses) and in October (for spring activates). Viable cities program could facilitate this for the broad area of smart and sustainable cities on a national level starting with a pilot event.

- Industrial and societal partners should be invited to participate in projects at a varying degree of open problem formulation meaning that the various variations of challenge driven courses need to be agreed upon and explained. Some courses could start with more well-defined problems, focus on innovative solutions, and go deep into the design and prototype phases whereas other courses should start with a completely open problem identification phase.

- Already existing collaboration in project courses should be included in the collaboration in order to draw on extensive experience in all schools at KTH and other universities.

Stockholm 2019-10-23

The Author

1 Background discussion and analysis

The discussions leading up to this essay started from the well-founded assumption that there is a huge potential for more collaboration between industry, society and academia (research and students) in the broad area of smart and sustainable cities. The overarching question/problem put forward initially was how to go about doing it. The ambition of this brief exploratory project aimed for the research program Viable Cities is therefore to reflect on this broad topic and provide experience and reflections and hopefully some useful advice and a potential process forward. I turned out to be a rather complex task.

As many problems identified in cities some colleagues even suggested that this problem even could be classified as a so-called **wicked problem**. Quoting Wikipedia means a problem that is difficult or impossible to solve because of incomplete, contradictory, and changing requirements that are often difficult to recognize[1]. Let´s hope it is not.

2 What does the stakeholders have to say about it and who are they?

Students of all ages love to work with projects with a strong coupling to real world problems. This is a well-proven fact. In recent year's sustainability has been a strong driver but it not the only one. Consequently, there are also many good examples where this is already done at our universities. So-called **challenge driven education**, or similar, is today also on the top of the teaching hype cycle (for good reasons).

Some forward-thinking teachers has for some time developed innovative course concepts that enables students to learn in an environment where problem definition and project work is well integrated with society. There is no lack in innovation but maybe there is a lack of competence and resources to scale it up?

[1] https://en.wikipedia.org/wiki/Wicked_problem#Related_concepts (assessed 2019-10-22)

Picture 1. Engaged third year students in Industrial economics and management playing a strategy game and developing incentives to steer the power market towards low-carbon technologies in course MJ1141.

Let´s introduce the other key stakeholders in this debate: We already mentioned the students and the teachers. We also have the program chairs and other academic leaders sometimes more troubled with overarching learning outcomes and national goals set up by the ordinance for higher education posing questions like:

"…Will the students reach their intended learning outcomes and can we prove it…? "…What about employability and attractiveness of programs…?

Obviously, the best and most secure strategy at the university is to aim for well- proven scientific depth within the chosen subject area. This has led to today´s rather conservative structure in programs. More on this challenge later.

On the other side of Valhallavägen[2] (as someone put it) other things matters. We have industries and society keen to employ new students with knowledge and skills that are both deep and broad but there is also a tendency for many representatives to recruit from their own program to be on the safe side. You know what you get.

However, there is also a search for creativity and innovative minds. Many employers therefore run extensive and expensive tests and challenges for students to find out who are the most creative and fast thinkers (especially the management consultant firms). Many of these tests deals with unstructured problems and challenges of a kind that could be trained already in the students' programs. It seems though that these recruitments are performed by experts within

[2] There is a similar expression at most universities

the organization or even as an outsourced activity and not necessarily by their future colleagues.

For most industries and societies (i.e. cities), there is also a complex trade-off between innovation and increased risk in their daily operations. Can they really afford to try new ideas and technologies not yet proven? If not, whom should prove them? Where can they test new idea without risk?

Already here we can identify some promising seeds for further elaboration. Entering into a closer collaboration between industries and other organizations (and their employees) with students already during their education should lead to even more successful processes for recruiting students. It also provides an arena for more explorative and risk daring projects. Since students will appreciate the work in collaboration these programs will be more attractive. If programs become more attractive, a larger number of talented students will apply and, thus, more students that are talented will graduate from the programs. This should make sense to employers. It should be a win-win. In system dynamics, this would be classified as a self-reinforcing loop.

3 What about multi, cross- and inter-disciplinarity?

Next area to discuss is related to the need to combine disciplinary knowledge and the broader experience of working in multi- or cross-disciplinary teams[3] since this is exactly what will happen when many students start to work anyway. Therefore, let's figure out how well suited smart and sustainable cities are for this. How multi- and cross-disciplinary is the quest for smart and sustainable cities?

The World Economic Forum, WEF, has undertaken a very interesting and ambitious works for their so-called global transformation maps[4]. The general idea is to help the users to explore and make sense of the complex and interlinked forces that are transforming economies, industries and global issues such as smart cities, renewable energy and so on. The idea is to visualize complexity and it aims to provide understanding over more than 120 topics and the connections and inter- dependencies between them. One such are is Cities and urbanization.

[3] There are multiple definitions possible but usually multi-disciplinarity is a lighter version of cross- disciplinarity where less effort is put on the learning between disciplines and more effort on the problem solving using each person's knowledge and skills. Next level would be interdisciplinary and transdisciplinary but those definitions are beyond the scope of this brief article.

[4] https://www.weforum.org/agenda/2017/11/what-is-a-transformation-map/

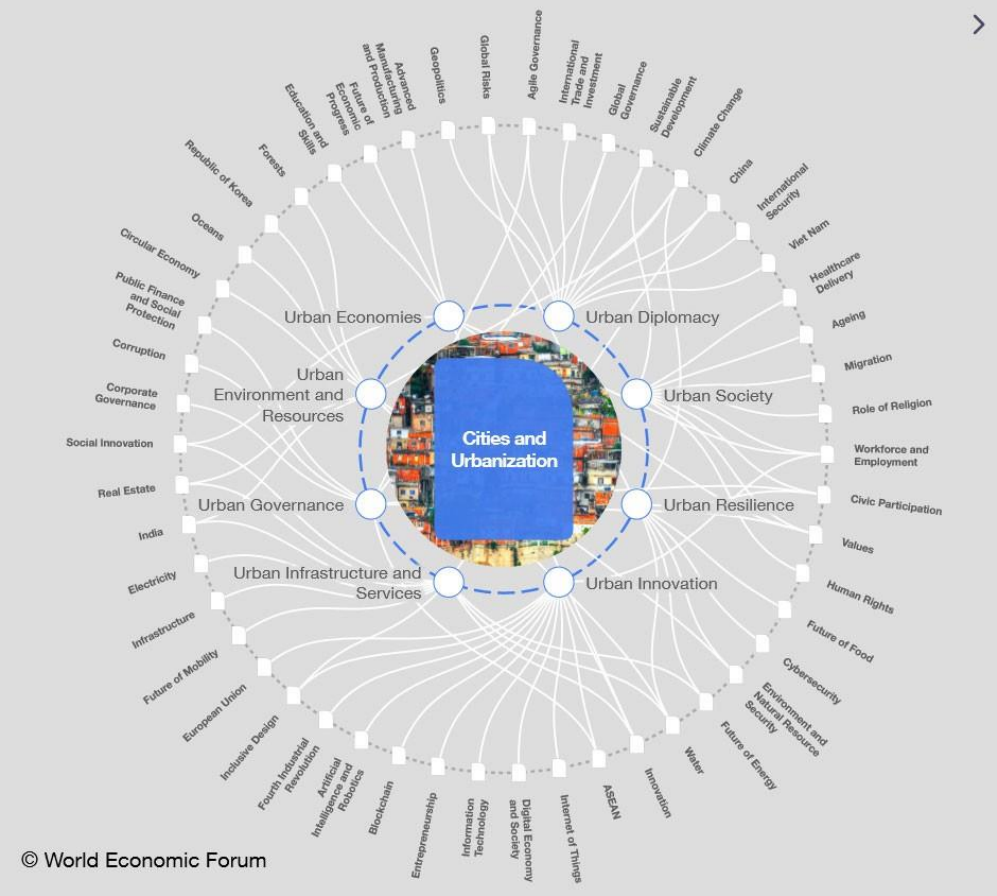

Figure 2. World economic forum transformation map for Cities and Urbanization

The central nodes are eight: Urban infrastructure and Services, Urban Governance, Urban Environment and Resources, Urban Economies, Urban diplomacy, Urban society, Urban Resilience and Urban Innovation. All of these broad central nodes are then connected to other peripheral nodes. Urban innovation is, for example, connected to Water, Internet of Things, Block chain, AI among others and Urban Infrastructure is coupled to mobility, electricity and so on.

One way to understand this diagram is that everything on the outer rim influences the development of cities in the future in one way or other. Obviously from the chart some nodes are quite special like India or China indicating regions with rapid urbanization but most other nodes represent research areas in themselves with their own experts and educational background in engineering, social science, political science, design and so on.

By inspection of the diagram, it is fair to say that the area of smart and sustainable cities and the associating urbanization is a truly cross- or even interdisciplinary area. It clearly reaches beyond traditional program boundaries at our universities. This implies that there might be a need to go beyond the trodden path for recruiting students to industry with a particular interest for cross-disciplinarity not as means to avoid depth but rather as a complement as new

and alterative skills. It is also fair to assume that typical programs run by universities like KTH not are designed to fulfil the aforementioned criteria.

It is in this area where we should seek out new collaborations and possibilities. We do not need to care about the already established collaborations within safe roads. We are looking for new ones. Therefore, the next more specific problem statements could be as follows:

How can we initiate new and innovative multi- or cross-disciplinary collaborations between industry, society and students? What is hindering it today?

One thing is clear: it is rather difficult for anyone outside established networks and collaborations to even approach a university such as KTH. How does one know whom to contact and when? Which program, school, teacher should be approached? How does the system work?

For those who have a background themselves at the universities many questions still remain. When is there a good timing for this during the academic year? Should students be approached in the 3rd or 5th year? Should "we" approach a course offering an inter-disciplinary approach or should we dig deep and safe into intra- disciplinary courses for best results? After all, we know what the problem is.

Similarly, it is quite difficult for teacher that want to reach out to approach industry or society outside the normal contact points, i.e. their normal field of work. It usually takes a lot of calling and emailing to find the right person in the right place at the right time. Imagine a teacher in Machine Learning and AI that seeks a project partner in the construction industry or vice versa. How can we formulate project to attract sustained interest from industry? How can teachers optimize the deliverables? How can we make sure that desired learning outcomes are met?

4 Do we need to explain the educational system? If so, how?

The educational system has changes over the year in accordance with European harmonization and an updated Swedish ordinance for higher education. We can say that there are two system running in parallel. The professional degrees such as "Civilingenjör" has its own specific learning outcomes and the B.Sc. and M.Sc. programs operate under partly different goals.

This is generally not considered as a big issue but it affects to what degree there is a freedom to design the students' program for more flexibility. More about that later. The Master level is typically taught in English and the programs holds a mix of students from Sweden and from abroad. The first three years, the B.Sc. part is normally taught in Swedish.

The implication of this is that projects run in year 4-5 (master) will deliver reports in English. The only exception here is the final thesis project that still can be in Swedish. However, an

increasing number of the native Swedish students also write their report in English as a preparation for profession work later on.

KTH educational structure matters (3+2)

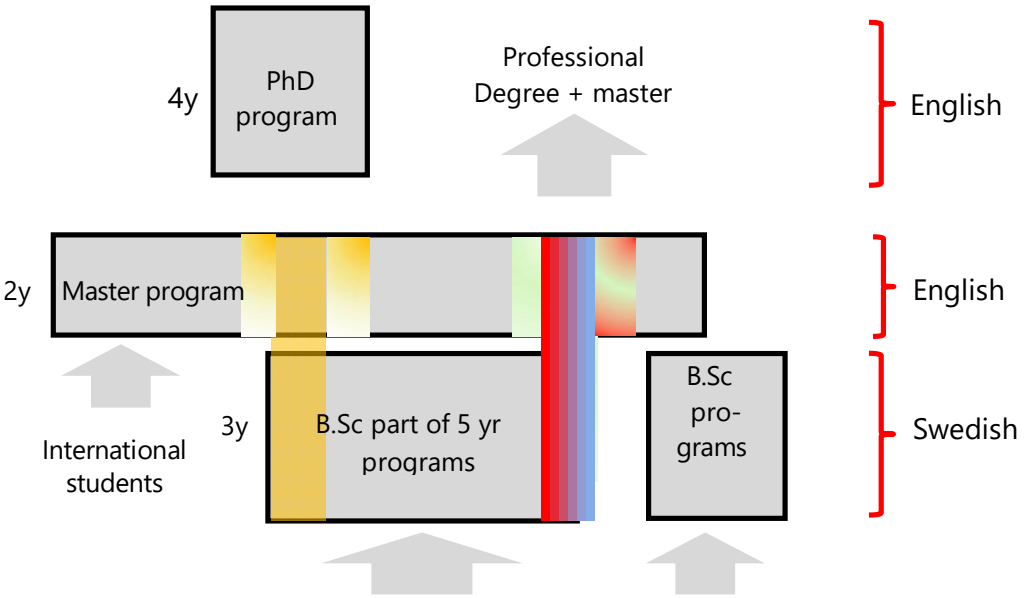

Figure 3. Education structure at Swedish universities in general and KTH. Students start at the bottom of the figure and work their way up the first three years. Most of them in so-called integrated 5yr programs. Some applied B.Sc. programs aim more directly at the labour market after three years. International master students typically enter year 4 after applying to master programs directly. Non-European students pay a significant tuition fee.

5 How does existing course fit in to "the system"?

Let´s use examples from two recent ambitious initiatives started at KTH. The first example is called Global Development Hub[5] an initiative to set up projects in collaboration with several African universities to work on locally formulated challenges driven by the 17 SDG's. The aim is to create mutual innovation capacity to contribute to solutions for major social challenges. The project is ambitious and provides both knowledge transfer between teachers but also a unique cultural experience for the participating students. A faculty program at KTH and partner institutes for teacher training has been introduced with an emphasis on coaching of student groups within creativity, innovation and entrepreneurship.

The second example is course given by Open Labs Stockholm[6] and it is a collaboration with other universities such as the Karolinska Institute and Stockholm schools of economics situated

[5] https://www.kth.se/en/om/internationellt/projekt/globaldevelopmenthub/uppdrag-och- mal-1.779721
[6] https://openlabsthlm.se

at KTH. Each university enrols the students in their own courses from an administrative point of view but all students participate in a common activity at KTH led by hired staff.

Both these projects should provide a platform for multi- and cross-disciplinary projects but it has been quite difficult to integrate these courses into the student's curricula. For the Global Development Hub the pathway chosen has been to enable the student to perform their B.Sc. thesis within the project which actually solves the acute key issue: where and when to fit it in? Where to find space? However, one major issue is that it is very resource demanding and difficult to scale up for more students. It also requires long distance travel, which may not be a desired way forward.

For the Open Labs project example, the course builds heavily on Design Thinking as the method but it has been hard for program chairs to deal with three fundamental issues in education: progression and overlapping learning outcomes and finally, the main subject of the course happens to be mechanical engineering. Students from different universities are blended together to solve problems identified by the city in Stockholm within four broad areas: Sustainable urban development, Aging population, Health and Education. Key issues here have been overlapping learning outcomes, difficulties to accommodate the course in the already tight curricula (15 credits) and difficulties to accommodate the subject area into student's master degree from a formal point of view. Other issues are concern about student progression in their own field of engineering. This is not a stated goal with the course but maybe it should be. Another issue might be the necessary teacher/coaching competence depending on the chosen projects.

Conclusions: both initiatives bring valuable experiences but none of the draws on the broad competence of the teachers and researchers at KTH. The Global development hub has selected a format that align with the program structures but it is difficult to scale up for more students. Open Lab courses mix students from many universities in various stages of the academic journey (on the progression scale). It is hard to see what a 5th year master student at KTH can learn from a 1st year student at Stockholm School of economics however interesting the project can be. Projects presented seem to be very conceptual and it is hard to see real solutions coming out. Another issue is how the problem formulation rights are distributed in the project. Projects seems to be rather well defined already when they are proposed.

6 What is challenge driven education?

One attempt to discuss various concept was presented at University of Tokyo in September in a symposium entitles "Innovation for Society". In order to discuss various types of challenge- or problem driven collaboration with society this attempt to define the process was presented by undersigned as figure 4.

The idea is that it is in fact possible to start anywhere where there is a "blue arrow" in the figure but those projects or courses are fundamentally different when it comes to problem

formulation, choice of method and intended learning outcomes. The loop is partly inspired by the so-called CDIO concept[7] (Conceive, Design, Implement, Operate) well known in engineering education pioneered by MIT in 1997 but also KTH and Chalmers University at early stages. According to this approach project should start with problem identification and problem formulation preferable in co-operation with an external stakeholder.

The challenge here is that often too much is given/decided at the start even if it serves well to provide the learning of engineering skills and provide good progression for students. A truly challenge driven project should start **one step earlier** with the broader challenge, the sustainable development goals, the messy and wicked problems. This means that those courses require multi- or cross disciplinarity for the initial problem formulating process.

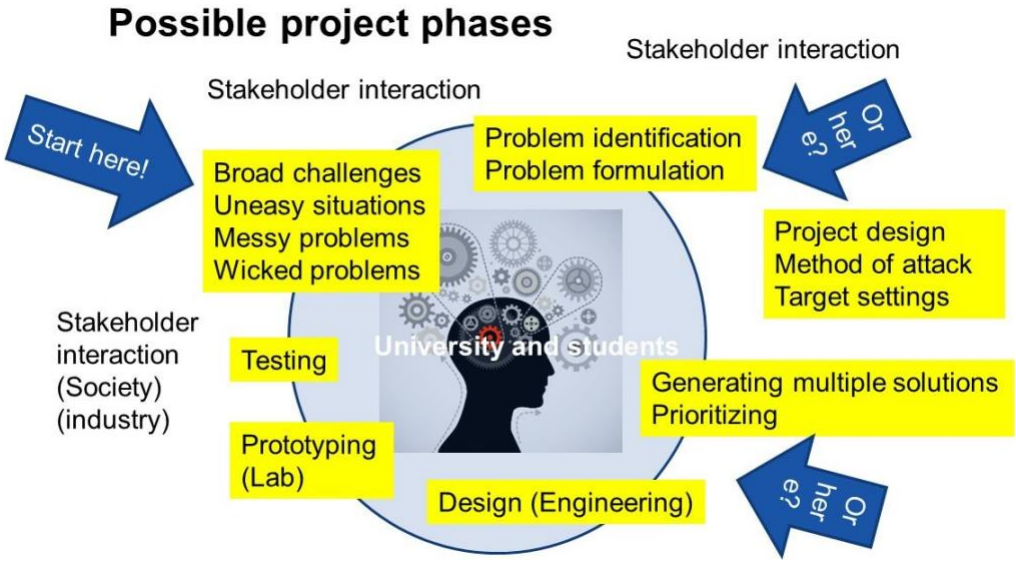

Figure 4. The challenge driven project loop – a prototype figure to facilitate discussion on different types of courses.

7 Progression matters in relation to x-disciplinarity[8]

A final discussion will be undertaken here in relation to progression in education. The diagram below is an attempt to map both various degrees of disciplinarity and progression. A blue circle with only red dots means that mechanical engineering students (red colour at KTH) only take this particular project course. Starting from the bottom is a blue circle with several colours illustrating that the students are coming from gymnasium level school (high school) and one

[7] http://www.cdio.org/
[8] Here x stands for multi, cross, inter or trans-disciplinary

cannot say that they are disciplinary at all yet but they have different experiences to draw from. Gradually the students develop an identity, a paradigm if you like, and it is possible to do something truly cross-disciplinary at master level.

Suitable progression in Education

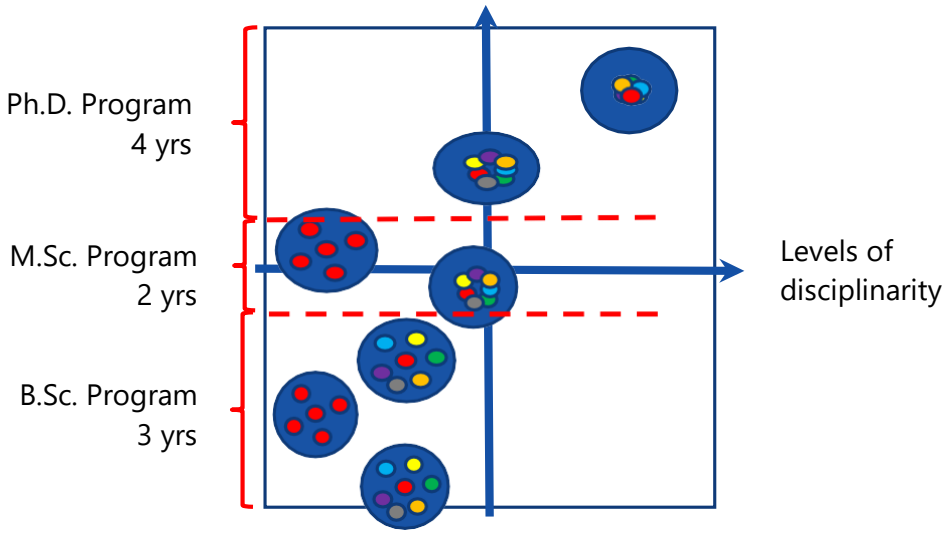

Figure 5: An idea how to map intra-, multi- and cross-disciplinarity and progression in educational programs. The tighter the dots the tighter the collaboration. Definitely work in progress…

8 Final comments

The aim of this short report was merely to "shake the tree" and see what comes down. Several activities should be undertaken to explorer it further. Still, the ideas put forward here have been tested on several colleagues and in the aforementioned workshop at University of Tokyo in September 2019. This does not necessarily mean that all agree.

Most important is to initiate the discussion with program chairs and program councils about freeing up space for challenge driven project courses. A discussion on learning outcomes and suitable examination is also necessary.

Secondly, a forum for exchange of ideas should be set up and a pilot project with match-making should be tried already this spring combined with workshops. This match-making needs to be done at least twice a year.

Good examples of courses and learning and coaching methods should be collected and shared among teachers and programs in a systematic way.

Finally, thanks to the Viable Cities program for supporting this brief study.

/The Author