

# Local communities of Computing Education in Norway

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**Abstract**— The paper seeks to examine how existing communities in computing education thrive in Norway and manage to empower school pupils and tutors realising their role in the digital society, learn programming, and become familiar with Computer Science and Information Technology. Two semi-structured interviews were conducted with organisers and designers of activities that promote computing education and programming in Norway. Also, one focus group discussion was conducted with high school students that participated in a small number of learning activities on design thinking, programming and Internet of Things. The results were qualitatively analysed using the Grounded Theory in order to conclude how different aspects (cognitive, social, organisational, policy) are manifested and interweaved in these communities.

**Keywords**— ubiquitous computing, mobile computing, Internet of Things (IoT), STEM education, local communities

## I. INTRODUCTION

The STEM communities in Norway are active schemata comprising a network of diverse stakeholders that have a vested interest in developing students' skills in the domain: formal learning in schools, as well as, semi-formal activities organised by third party initiatives, such as code clubs, science centers, teacher training events, outreach programs for kids or young women etc. The latter category integrates a complex grid of activities which are supported by sources like the municipality, the university, the state and the industry. Also, volunteering seems to thrive in this network. The local communities that this paper focuses on function as a catalyst of unleashing the students' potentials with respect to 21st century thinking skills in conjunction with STEM while trying to inspire and motivate students. In doing that, they might focus on social aspects (e.g. the gender gap in STEM) and/or the cognitive aspects (e.g. computational thinking skills). The rationale is to help students to understand not only the principles behind the use of technology but also why it is important for the society.

Nowadays, the prevalence of computing technology in Norway is evident in the everyday lives of the people [2]. Largely, the curricular and/or extracurricular activities performed by the students that participate in the local communities at stake in this paper, revolve around processes that help them understand the importance of acquiring knowledge and competences in computing technology and programming. This might encompass scientific knowledge, but also practical experience, as well as, action-oriented and context-related processes. Activities organized within the school system as part of a general studies program might focus more on the former aspect, whereas in other social learning systems in which

extracurricular activities are organised by third party initiatives, the focus might be placed more on the latter aspect. Regarding the educational context in formal education, a pilot program has started from autumn 2016 in Norway launching an elective course on computing education with 146 participating lower secondary schools, at present [14]. In primary education, technology has been part of the Norwegian curriculum since 2006 in the form of an obligatory multidisciplinary course on design and technology. Finally, in upper secondary education there are more options with separated courses for computing and programming specialization.

It has been suggested that, although the promotion of STEM among the school population has received much funding, research in computing education merely remains underfunded ([7],[16]). Conversely to that, the UMI-Sci-Ed project (reference) is an ongoing Horizon2020 project funded by the EU that seeks to exploit Ubiquitous Computing, Mobile Computing and the Internet of Things (UMI) to promote science education. In doing that the project will investigate the drivers and the barriers concerning UMI science education and build sustainable Communities of Practice (CoPs) that revolve around it. Along these lines, the UMI-Sci-Ed project will propose solutions that link together the school, the local communities, the industry and third-level initiatives already active in the domain. The most effective way to accomplish this is to build these CoPs within active clusters where a body of accumulated knowledge already exists. The rationale is that CoPs will be formed dynamically around UMI-Sci-Ed projects including diverse perspectives, ideas and experiences coming from representatives of all stakeholders. In the context of this paper, local communities and Communities of Practice differ in terms of both scope and scale. In fact, CoPs is a much broader term which spans across contexts. Consequently, local communities which are generally restricted to some geographical areas is just one case.

## II. RESEARCH PROBLEM

The core objectives of the project are: a) developing novel educational services for young students, including guidelines for UMI learning under the CoPs format, roles and structures, b) supporting promising scientific careers by providing career consultancy services, c) ensure gender equality and d) promoting formal and informal science education, focusing on UMI. More specifically, the CoPs aspect is investigated across three dimensions: what it is about, how it functions and what capability it has produced [15]. The purpose of this paper is to explore the landscape in terms of local communities that are active in UMI-Sci-Ed topics in Norway and get an idea of who

is doing what in this communities as well as understand their specificities and their local character.

### III. METHOD

#### A. Participants

There are two different types of participants in this research: secondary education pupils or organisers/ designers of UMI-Sci-Ed activities. Regarding students, five upper high-school students, four boys and one girl (all of them Norwegian) were included in the sample. They had already participated in a small number of UMI-Sci-Ed activities organized by researchers of the Department of Computer and Information Science of the Norwegian University of Science and Technology. In particular, they participated in the following activities: a) Scratch activities in tandem with Arduino and robot animals, b) TILES design workshop [11] where they used a toolkit to facilitate the transition from design to programming, in tandem with IoT-infused application and c) 3D printing activities. Also, they had attended a presentation about visual programming in Scratch-like environments. In addition, they had participated in an eye-tracking activity while playing a computer game.

Regarding organisers and designers of UMI-Sci-Ed activities, two male participants were interviewed. The first interviewee (P1) was the project leader of Lær Kidsa Koding [10]. Lær Kidsa Koding (LKK) is a voluntary movement in Norway working with children and youngsters in order to help them realise their role in the digital society, learn programming, and become familiar with Computer Science and Information Technology. The courses that are currently available are: 1) micro:bit, 2) Scratch, 3) Python, 4) LEGO Mindstorms, 5) Web, 6) App Inventor, 7) CodeStudio, and 8) ComputerCraft. The project leader is a Norwegian male around thirty years old. In addition, LKK organizes teacher conferences that aim to empower teachers to act as change agents in conjunction with STEM (focusing on technology integration) in their respective schools.

The second interviewee (P2) is an Associate Professor in the Department of Computer and Information Science (IDI) in the Norwegian University of Science and Technology (NTNU). He is Norwegian around fifty years old. He is actively involved in the Kodeklubben society in Trondheim, Norway [10]. It is a movement affiliated with Lær Kidsa Koding and it is run by volunteers. The courses are held in the premises of the Norwegian University of Science and Technology. The participant pupils are supported mostly by university students. The courses that are currently organised by the Kodeklubben society in Trondheim: 1) Scratch, 2) Python, 3) ComputerCraft, and 4) Java. The interviewee is responsible for the Java course module running in Kodeklubben.

#### B. Instruments

Two instruments were used: a focus group protocol for students that have participated in UMI-Sci-Ed activities and a semi-structured interview protocol for designers or organisers of UMI-Sci-Ed activities in already existing communities. The focus group protocol is addressed to participant students and, in its final version, is complementary to a questionnaire that is being used internally in the UMI-Sci-Ed project and has been designed by the Computer Technology Institute and Press

“Diophantus” project team in Greece, who are the project coordinators. Also, it is complementary to the evaluation questionnaires of the UMI-Sci-Ed activities that are organised by the researchers of the IDI at NTNU. Example of such activities include the Kodeløypa initiative [5] and the TILES design workshop, mentioned above. These two instruments capture relevant to the research problem aspects using quantitative methodology and a Likert scale; they seek to answer the ‘what’ question and to get an overview in order to obtain a holistic idea of the UMI-Sci-Ed CoPs. The resulting protocol seeks to answer the ‘how’ question in some selected aspects that it is intended to get more in-depth insights. Also, the scope of the instrument is different, since it is addressed to local societies of Norway and aims, among others, to uncover their specificities.

Regarding the protocol that was used to interview organisers and or designers of UMI-Sci-Ed activities, after reviewing the literature the authors concluded that, there is a lack of previous similar standardised instruments that would be suitable and that could be reused for the purpose of these interviews, that is to explore the landscape in terms of local communities that are active in UMI-Sci-Ed topics. Thus, this instrument was created from scratch, validated with two researchers and pilot-tested with one of the interviewees. It covers five different aspects of UMI-Sci-Ed communities: 1) General information about the participants, 2) UMI-Sci-Ed aspects, 3) community aspects, 4) Other aspects (sponsorships etc), 5) Connection to the UMI-Sci-Ed project. A modified version, which additionally covers a sixth aspect related to educational policy, was also created. It is targeted those organisers of UMI-Sci-Ed activities who are also policymakers, that is, they are in a position to affect educational policy at a national level on the topic at stake.

#### C. Procedure

Semi-structured interviews were conducted with the adult participants and a focus group discussion with the pupils. The interview presupposes a ‘bottom-up’ approach towards UMI-Sci-Ed communities, that is, knowledge elicitation about UMI-Sci-Ed communities derived from the ‘end-users’. Also, that a prior investigation has taken place in order to identify local initiatives or communities active in the field. Before the beginning of the interview, the interviewees were informed about the UMI-Sci-Ed project and how this interview serves the objectives of the project and the objectives of the research work. The duration of the interviews was no more than forty minutes. The interviewer asked permission to record the interviews and explained how the recorded data would be protected and used.

The ensuing interviews transcripts were analysed using the Grounded Theory [6]. It entails text analysis through the emergence of concepts, categories and codes grounded from the data. The data are analysed with an open mind on behalf of the researcher while having no preconceived hypotheses [1]. The GT approach is an inductive, comparative and iterative method for analysing qualitative data. The added value of the approach stems from the fact that its procedures “are designed to develop a well -integrated set of concepts that provide a thorough theoretical explanation of social phenomena under study” [4]. The purpose of GT is twofold: describing and explaining the social phenomenon at stake, which was needed herein. The GT

approach was suitable in the context of local UMI-Sci-Ed communities since there is limited evidence in the literature that would support any pre-established hypotheses on the topic at stake. After the analysis using the GT, and the emergence of concepts, categories and codes two informal models were created for the model of the local UMI-Sci-Ed communities, one from the perspective of students (stemming from the focus group analysis) and one from the perspective of designers and/or organisers of communities (stemming from the two interviews). The informal model is a visualisation of the codes, concepts and categories emerged in conjunction with GT in order to provide a visual representation of the analysis findings [8].

Finally, for each interview a basic text analysis was conducted automatically using a word cloud generator application.

#### IV. RESULTS

Regarding the word clouds which were automatically generated for each interview, the most common words (i.e. frequently used by the interviewees) are depicted in Figure 2 and Figure 3. The informal model representing the findings of the interviews analysis is depicted in Figure 1. The codes emerged are depicted with rectangular shapes in the model and the concepts are depicted with elliptical shapes. Some concepts were further grouped conceptually into categories. They are denoted in the model with elliptical shapes which have double lines around them: Learning activities-materials, Resources, and Community.

The findings of the interviews analysis using GT can be summarised as follows: the learning materials used contain step-by-step explanations targeted both for the facilitators (tutors, student assistants, parents or others) and for the students; they are interesting for the students, joyful and practical. Also, the materials are as self-explanatory as possible and have different levels of difficulty. There are no formal methods for student assessment and/or learning activities evaluation embedded in the learning activities. As participants said: "we would like to cooperate (with the university) in evaluating the impact or the effect of these activities in a micro-level (i.e. where the unit of learning is the learning activity)" (P1) and "what I have seen is that those that who are engaged usually come back because they want more" (P2). The most common types of learning materials are: exercises, examples or projects. Regarding the community aspect, there are several roles undertaking different tasks: students, facilitators (student assistants, tutors, experts), people who affect strategic decisions, course developers and parents/legal guardians. The concept of the philosophy and the ethics that traverse the community is crucial and is related to the use of open source software or freeware, volunteering, being open and sharing (materials, experiences, ideas), and cooperating with other similar communities. The type of learning promoted in this learning ecosystem is away from any instructionist model and close to constructionism. A few excerpts from the interviews that exemplify this: "you actually create something: a game or an app or a webpage or a small program that is visual or physical, every time" (P1) and "I hope that they implicitly learn some principles from doing practical programming activities, and gain a deeper understanding" (P2).

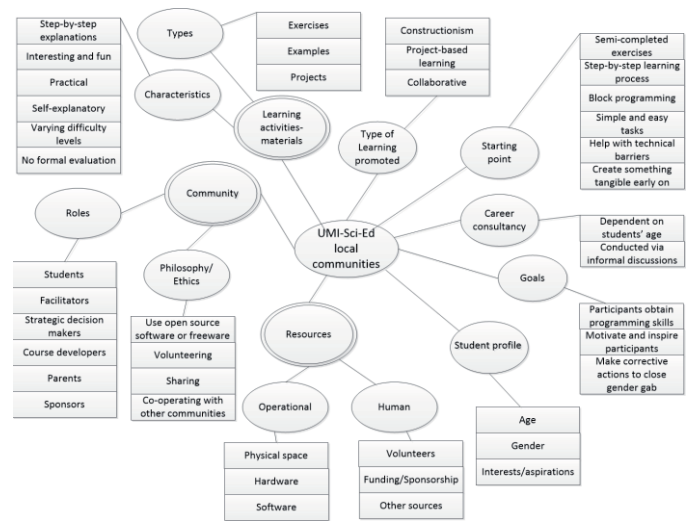


Fig. 1. Informal model of UMI-Sci-Ed local communities (from the perspective of organisers and/or designers)

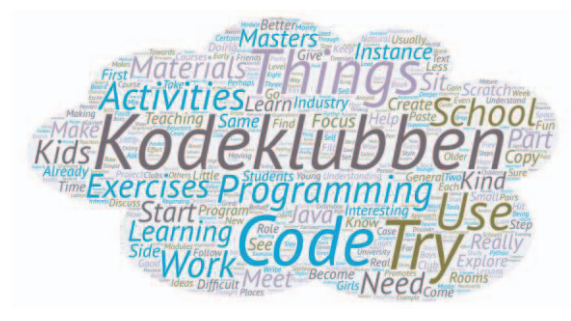


Fig. 2. Word cloud automatically generated from the interview of the person who is responsible for the Java course in Kodeklubben at Trondheim, Norway

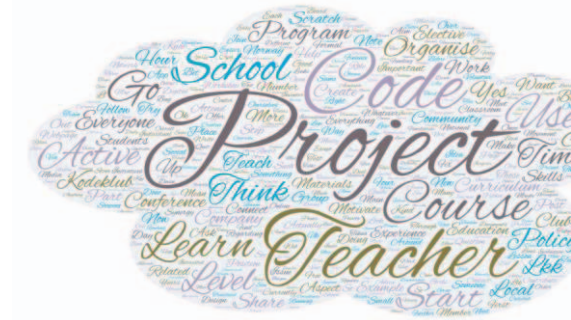


Fig. 3. Word cloud automatically generated from the interview of the project manager of the Lær Kidsa Koding society in Norway

It promotes project-based learning, collaborative learning and discovery/exploratory learning. In conjunction with the resources that are needed to sustain the community, they are categorised in two types: operational and human resources. The former involves the use of a physical space, the hardware and the software. Sponsorships and synergies cover this aspect. The latter involves volunteers, funding for recruitment (coming from the industry sector or universities etc) and other sources. Important characteristics of the student profile in this context are



the age, the gender and their aspirations or interests. Associated with the gender aspect is the fact that in the more advanced courses the number of girls dropping out increases dramatically. The main goals of the local communities examined is to empower their participants with programming skills, to motivate and inspire them to learn programming and to make corrective actions to close the gender gap. A few characteristic interview excerpts: “(the goal is) not only to familiarise teachers with projects related to coding/programming but also to further motivate and empower them to be in order a position to try out on their own” (P1) and “we have been thinking of having girls-only timeslots” (P2). Regarding the career consultancy aspect, it is dependent on students’ age and it is conducted informally at some extent via discussions of the students with experts or professionals from the industry or with the university students. The starting point is a crucial theme and many codes emerged around this concept: semi-completed exercises, step-by-step processes, use of block programming (e.g. using Scratch-like environments), simple programming tasks, help with technical barriers (e.g. setting up laptops), create something tangible early on in the learning process and engage with easy exercises and examples. In general it seems that the learning process model is dependent on familiarization of people involved with programming and/or engineering and the relationship with the school curriculum (complementary, aligned, no relationship). The informal model representing the findings of the focus group analysis with the students is depicted in Figure 4. The findings of the focus group analysis using GT can be summarised as follows: regarding students’ prior ideas on UMI, it is advisable to explore them at the beginning of UMI-Sci-Ed activities. Today’s children are digital natives who are surrounded by technology in their everyday lives, consequently is its high probable that they might join a group/community having at some extent their own preconceived ideas. Thus, the UMI-Sci-Ed activities might actually change their preconceptions. Students might have some initial ideas on UMI from their everyday-life experiences (i.e. smartphones). And UMI-Sci-Ed activities can help them understand “how it works” (as the participant students said), obtain more technical knowledge and gain personal meaning of UMI. For example, the students that were interviewed were, after the end of the UMI-Sci-Ed activities, able to explain in their own words what UMI means for them. In addition, the activities might help students destabilise any misconceptions related to UMI. For instance, the students of the focus group were surprised that sensors could actually be embedded to almost all everyday-life objects (i.e. clothes, pizza, fridge etc). Regarding skills development, it seems that students believe that UMI-Sci-Ed activities could foster the development of technical skills but also encourage creativity and creation through interdisciplinary projects. Also, they can promote collaboration through brainstorming, discussion and peer learning. These skills can be later on transferred to other similar contexts. Concerning software tools usage, an emerging concept refers to a learning ecosystem in which they are used in tandem with physical artefacts and the ‘learning by doing’ approach. Also, it is important that they are user-friendly. Finally, about the use of social media tools, the students of the focus group said they would use them mainly for reflection. In relation to difficulties that may come up, it is important that students are familiarised or get extra support with a) programming when

working with IoT applications and b) the ‘learning by doing’ approach. Regarding learning materials perceived as being the most useful from the students were either in the format of tutorials or in the format of easy introductory tasks.

Finally, the concept of feedback emerged: instant instructional feedback was valuable for students. This instant feedback was stemming from the fact that students could see the immediate results of their actions during the UMI-Sci-Ed activities. For example, while they were creating their IoT applications. Students found useful the feedback in the form of comments at the end of each task coming from the facilitators. Also, they appreciated the feedback coming both from peers and the facilitators.

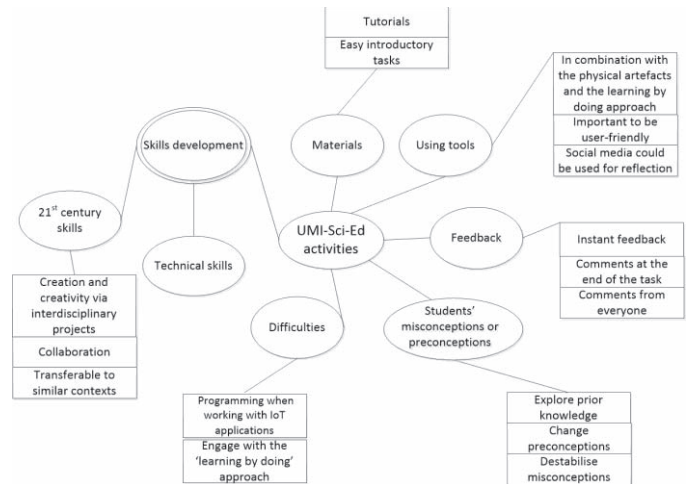


Fig. 4. Informal model of UMI-Sci-Ed activities in local communities (from the perspective of students)

## V. DISCUSSION AND FUTURE WORK

When comparing the two informal models and the associated findings from the focus group and the interviews, it can be concluded that the starting phase is crucial for both students and tutors, especially if they are not familiarised before. This seems to be in line with the idea of “low floor, high ceiling” which was suggested as one of the guiding design principles for programming environments for children many years ago [7]. In the context discussed herein, this idea means that it should be easy for a beginner to reach the threshold of creating something tangible like an IoT application or a computer game using block programming. At the same time, this principle caters for the creation of computationally rich environments [7]. Herein, that means that it is advisable that the UMI-Sci-Ed learning scenarios have different levels of difficulty in order to challenge every student, including those who are competent in programming. Also, a common point in both cases (that is, the focus group discussion and the semi-structured interviews) refers to the adoption of a step-by-step learning process especially in the case of beginner students or tutors. Finally, it has emerged that the UMI-Sci-Ed activities have the potential of cultivating 21st century skills in combination with STEM skills. The cultivation of the 21st century skills aims to prepare the students for the future and can be categorized broadly as follows [12]:

- Learning and innovation skills: creativity and innovation, critical thinking and problem solving, communication and collaboration
- Information, media and technology skills: information literacy, media literacy, ICT literacy
- Life and career skills: flexibility and adaptability, initiative and self-direction, social and cross-cultural skills, productivity and accountability, leadership and responsibility.

In particular, the findings indicate that through the activities performed skills like creativity and collaboration in conjunction with ICT literacy can be promoted.

Stakeholders play a crucial role in every project. Stakeholders can be defined as individuals or groups that have a vested interest in a project and its activities [3]. The preliminary analysis of local stakeholders described herein aims to evaluate and understand local stakeholders in order to determine, among others, their relevance to the project and their different perspectives [13]. Regarding the identification of the local stakeholders, we use the snow-balling sampling method, as suggested by Reed et al. [13]. It is an iterative process which involves pre-identifying initial stakeholders, interviewing individuals from the sample of initial stakeholders, and identifying new stakeholders and contacts. Future work includes more interviews at least until a saturation point is reached, in which no new concepts, categories or codes emerge anymore. Limitations of this work include a) that the number of participants is low and b) the scope of the research work (i.e. to explore the landscape in Norway). These limitations makes the findings prone to being context-dependent, as opposed to being generalizable.

The methodology described in this paper will help the project team in Norway to conclude who these stakeholders actually are, what are their main tasks and how can they embark in the UMI-Sci-Ed learning ecosystem that is shaped in Norway. The UMI-Sci-Ed project will deliver training mechanisms and educational service methodologies that are framed within true implementations of the CoPs format, recognising that communities, schools and other organisations innovate in this domain and meta-level synergies can be created. To this end, future work also includes the investigation of how local communities will flourish as part of a UMI-Sci-Ed CoP across contexts and boundaries.

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