Educational Support to Develop Socially Disadvantaged Young People's Digital Skills and Competencies: The Contribution of Collaborative Relationships toward Young People's Empowerment

Toshinori Saito [1][0000-0003-4262-9707]

[1] Seisa University, Yokohama/Kanagawa, Japan
t-saito@gred.seisa.ac.jp

Abstract. Digital skills and competencies are necessary for thriving in the coming digital society, and it is important for youths to gain these competencies as well as to become empowered as actors in the digital environment. This paper contends that collaborative relationships established as part of an educational support group to develop socially disadvantaged young people's digital skills and competencies positively impact their empowerment. We discuss the findings of four years of action research among a support group for socially disadvantaged youths in a provincial city in Japan. The results suggest that the collaborative relationships established within an educational support group can create a rich learning context and foster collaborative agency for youths. Moreover, computer programming carried out in the context of these relationships may generate cooperation and a unique programming culture shared among the youths.

Keywords: Digital Skills, Collaboration, Empowerment, Programming.

1 Introduction

Digital literacy and competency are now fundamental to forming civil society. In recent years, several frameworks have pointed to the importance of knowledge, skills, competencies, and attitudes toward digital technologies. These frameworks provide a perspective on simple digital technology use and complex activities such as "communication and collaboration" or "problem-solving." For example, the European Commission's Digital Competence Framework for Citizens (DigComp 2.0) [1] and UNESCO's Digital Literacy Global Framework [2], based on a review of DigComp 2.0 and other global examples of digital skill frameworks, both refer to a comprehensive, synthesized competence model for digital technology use and for activities emerging from its use by defining several competence areas as targets for improving citizens' digital skills.

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However, few studies provide insight into the specific processes through which citizens acquire digital literacy and competency. Several have focused on linking computing to social participation. For example, Wagh, Cook-Whitt, and Wilensky [3] demonstrated the potential for inquiry-based learning through interaction with program code, using the concept of computational engagement in a K-12 science education case study. They showed that the acquisition of programming as a component of digital literacy and competency not only involves learning computing skills but also has the potential to elicit an inquisitive attitude in learners. A case study by Yu, Ruppert, Roque, and Kirshner [4] addressed youth participation in civic activities as promoted through computer programming projects based on a conceptual framework of critical computational literacy. The study demonstrated, based on observations of after-school activities, that creation through computer programming can lead to young people's social participation. In presenting the concept of computational participation, Fields, Kafai, and Giang's studies [5][6] analyzed the influence of social aspects (e.g., gender gap) on children's participation in programming in the Scratch community. They argued for the need to understand the sociological and cultural aspects of learning to code. Further, a study on computational empowerment by Iversen, Smith, and Dindler [7] suggested that support projects should aim not only to help children acquire digital literacy but also to enable them to make critical decisions about the role of technology in their lives.

Like these studies, this paper assumes digital literacy and competency acquisition as a learning goal for children and all citizens. In contrast, however, the focus is explicitly on educational support as part of social participation support for young people in socially difficult situations. Further, the research is about the empowerment of the young people in the support group, including lay supporters who do not have expertise in digital technology, conducted by university educators in computing education.

Correspondingly, this paper discusses the contribution of participants' collaborative relationships toward empowerment in the context of a program for educational support for digital skills and competencies (ESDC) for socially disadvantaged youths [8]. The aim is to develop a better understanding of the benefits of having young people participate in an ESDC program as members of a voluntary group rather than as isolated individuals. For this purpose, the study views empowerment as a regaining of people's ability to choose to engage in digital technology in a way that they cannot in isolation. This idea takes over the sociological understanding of empowerment as a reciprocal change in an individual and their surrounding circumstances through the restoration of the denied possibility of choice, which is integral to human agency (see [9][10]).

Thus, this paper investigates the contributions of collaborative relationships within the context of ESDC for socially disadvantaged youths living in a mid-sized provincial city in Japan. For this purpose, the author conducted a participatory study to help youths learn about computing. The following two research questions are addressed:
RQ1. How can collaborative relationships among participants contribute to the empowerment of young people in the context of ESDC?
RQ2. What educational significance can be ascribed to computer programming carried out in collaborative relationships within an ESDC program?

2 Relevant Literature

Findings from collaborative learning research provide implications for the type of collaborative relationships investigated here. Anderson [11] pointed out the importance of evaluation equality among participants in collaborative work. Baker [12] described collaborative situations as characterized by members with different qualities but equal status and rights in the interaction, problems requiring collaboration, a high degree of joint attention and synchronous interaction, certain problem-solving procedures, a purpose of understanding collaboration beyond reaching a correct answer, and support through Vygotskian scaffolding. Both studies highlight equality-based interrelationships and respect for diversity in capacities among members of support groups.

To understand the contribution of collaborative relationships in the ESDC group, the author focuses on shared culture, mutual trust and interdependence, and agency, following the previous studies. Kucharska [13] pointed out that collaborative culture and trust shared among project members coexist and support each other in a project setting facing external conditions of cooperation, complexity, the uncertainty of environmental conditions, time, and budget pressures. Yoda [14], in discussing collaborative relationships between physicians and engineers in medical device development settings, noted the importance of education, geographic proximity, good leadership, and individuality of members to create collaboration across cognitive, organizational, social, and institutional barriers. Meirink, Imants, Meijer, and Verloop [15], in their research on teacher development settings, found the important of balancing two seemingly conflicting elements: a high level of interdependence and autonomy of each member.

This research continues the focus of previous studies that have revealed the importance of collaborative culture and methods in creative activities, including computer programming. Kucharska and Kowalczyk [16] found that a collaborative culture in team project management, along with trust and shared tacit knowledge, is deeply involved in value creation in projects. Sawyer's [17] investigation of creativity-driven design education found that collaborative and interactive processes are essential for improving performance in knowledge construction. In computer programming, from the viewpoint of productivity and quality improvement, cooperative programming methods and systems have been developed to support software creation (see [18][19]).

Expanding on the previous works, this paper emphasizes the emergence of social participation rather than the quality of the programs produced or the improvement of the participants' programming skills. Studies that are closer to the present research are Peppler and Kafai [20] and Kong, Chiu, and Lai [21]. The former focused on the importance of collaboration in media art production in design studios, reporting that young people learned computer programming from the perspective of social participation and were motivated by working with peers and mentors to create and share their work. It also noted that collaboration is an indicator of higher membership in the community. The latter revealed that students with better attitudes toward collaboration had higher creative self-efficacy but not programming self-efficacy. It also noted that students might view collaboration positively as a means of enhancing creativity to

solve programming challenges when they cannot generate sufficient ideas on their own.

3 Methodologies

Action research (AR) was adopted as a participatory research method. In the AR approach, participants seek positive social changes based on democratic values [22] by exploring solutions to problems [23]. AR requires a shared vision among researchers and other participants concerning the process and problem-solving goals, and in this process, learning through shared reflection among participants is highly valued [24].

AR was implemented in a support group for disadvantaged young people. The author and group members worked together to establish ESDC as a new option for supporting young people's social participation. This paper describes the findings of reflective exercises conducted within the group, from the perspective of youth empowerment.

For the participatory study, the author engaged in the group's activity, aiding the youths' rehabilitation and social participation. The youths in the support group were experiencing social withdrawal or school absenteeism. The group met in a mid-sized provincial city in Japan and varied in size during the study period from one to ten young people with two to five staff members, either full-time or part-time. The author acted as a part-time supporter, assisting the young people in learning computing and informatics.

The study commenced in May 2015, following a similar pilot study from December 2013 to January 2014, and finished in March 2020. The findings are based on an analysis of field notes written for eight days every Thursday from June to August 2016. During this period, the author and youths were involved mainly in computing and informatics learning through a project to construct a programmable robot called Mugbot, which is an open-source social robot.[1]

Data were collected in the form of field notes, text descriptions with some pictures and videos, observations of events and occurrences, dialogues with the participants, and reflections on every session during the study period from June 23, 2016 to March 9, 2020, which constituted a 147-day record[2] written originally in Japanese. Interviews were not used as the pilot study showed that they may cause tension in young people.

The data were coded by thematic analysis [25] [26] using NVivo. First, the author scrutinized the field notes to identify themes related to the research questions [26] and concepts relevant to each theme. Because the only academic member in this study was the author, peer review did not verify the coding. Instead, at the end of each day in the support group, the author disclosed the interpretation of the day's events to the participants (i.e., young people and support members), asked for their opinions on its validi-

[1] Mugbot was initially designed by the Koike Laboratory in Tokyo Metropolitan University http://www.mugbot.com

[2] The typical length of a day's field notes was approximately 1,000 to 2,000 words in English.

ty, and incorporated their ideas into the field note descriptions. Initially, 43 subcodes emerged from the field notes. Then, by inductive categorization, these codes were classified into nine abstract code categories as Table 1 shows. The author then reinterpreted the coding results to determine themes and issues essential to the research questions. Full ethics approval was obtained from the Research Ethics Committee of Seisa University (No. 1613).

Table 1. Code from thematic analysis.

Code name	N.E.S[3]	N.R.F.D[4]
Foundations of autonomy in community culture	8	39
Opportunities to acquire digital competencies associated with coding	7	16
Two values that programming involves (instrumental value, intrinsic value)	2	6
Learning in the local community	5	10
Watching over as moral support	3	14
Life fulfillment of participants arising in the support	4	23
Agency of participants at the center of the support	4	43
Intervention with participants by supporters	6	20
Transformation of participants through group activities	4	12

4 Findings

Based on the data analysis, four thematic topics emerged: (1) Role identities formed among the young people in collaborative relationships within the ESDC group added the meaning that programming was an activity leading to social participation; (2) In the programming projects, the participants' voluntary group contributions and resulting learning drove their acquisition and proficiency in digital literacy and competency; (3) Programming became a proactive learning experience for the young people due to their trial-and-error attempts to solve issues; and (4) Programming changed its status in the group from an individual practice to the group's culture when group members' active engagement with programming became part of their collaborative relationships.

4.1 Role Identity Adding Meaning to Programming As Social Participation

Role identity, or the imaginative view of oneself as being and acting as an occupant of a certain position [27], seemed to add meaning to computer programming as an activity leading to the young people's social participation. The young people helped facilitate the projects they engaged in, forming their role identities in a collaborative relationship. For example, two participants who were both in their late 20s and had experienced school drop-out and social withdrawal ("Y1" and "Y2") started their Mugbot

[3] Number of Encapsulated Subcodes
[4] Number of References to Field notes Description

production project after they happened to see a demonstration of Mugbot programming at "Scratch Day in Tokyo," a significant event for Scratch programmers. They naturally established a division of tasks based on their respective areas of expertise and helped each other, and this task division later became established as their role identities. For them, mutual assistance based on their role identity in the project seemed to be virtual social participation in that it involved responsibility for others. Tables 2 and 3 show excerpts from the field notes suggesting the task division.

Table 2. Excerpt from field notes, June 23, 2016.

Although Y1 maintains the attitude that he has no idea about hardware, he is happily inputting programs on his PC (Y1 is rather talkative when he is having fun). This attitude suggests that he takes pride in his role as the software developer while Y2 takes care of the hardware. (June 23, 2016)

During the project, a role identity emerged for Y1 and Y2, where Y1 was in charge of software implementation and Y2, hardware assembly. Y1 learned to program first and took the lead in dealing with complex issues that arose when controlling the Mugbot in collaboration with the author. Y2 worked to understand the program with the help of Y1 while assembling the hardware. This role-identity-based assignment drove their participation in the project for over two months.

Table 3. Excerpt from field notes, August 24, 2016 (1).

Y1 and Y2 are proceeding with Mugbot production with some degree of autonomy. >>Y1 has been working on the software part of Mugbot's production by himself, reading texts and making full use of search engines. Recently, Y1 has voluntarily submitted progress reports and meeting requests to the author. >>Y2 supports Y1's work, mainly by wiring Mugbot. This role division was decided based on Y2's wishes. (August 24, 2016)

Y1 and Y2 seemed to give programming different meanings based on their role identities, while programming was the common foundation of their collaborative relationship. For Y1, learning and practicing programming was participation in the collaborative relationship by contributing to the shared goal of facilitating the Mugbot production. For Y2, assembling the Mugbot hardware was his role in the project. In addition, Y2's programming learning was a sincere response to Y1's help and preparation for participating more deeply in the project within the collaborative relationship.

4.2 Active Group Contributions and Resulting Learning As Drivers of Digital Literacy and Competency Acquisition

In projects such as making Mugbot or teaching programming classes for kids, which included programming opportunities, the participants' active group contributions and resulting learning drove their acquisition and proficiency in digital literacy and competency. On many occasions, the participants, including the staff, contributed to the projects' progress according to their interests. Their contributions to the group inevitably required more digital literacy and competency than they held, and to meet the

requirements, they had many opportunities to develop greater digital literacy and competency.

Table 4 presents a scene in which the organizer of the support group (S1) and Y2 spontaneously introduced Scratch programming to group members who were less familiar with it. This demonstrates that teaching programming to each other had become an established culture within the group. In support of this culture, Y2 and S1 learned to program in order to teach it to others.

Table 4. Excerpt from field notes, August 24, 2016 (2).

Below is how the support staff (S1, the support group organizer) came up with the idea of introducing Scratch to a teacher in training in the group (T1), a high school student who had come to observe (H1), and a former group member (H2) who had come for a conversation, and how Y2 was able to help them do so immediately (with no specific request or advice from the author). >>S1 approached T1 and H1, who were in the meeting room, and encouraged them to gather in the learning space. S1 then approached Y2 to set up a laptop computer (purchased with a local government grant) on a table in the study space. >>In addition, S1 introduced Scratch programming to H2, who came later, and encouraged him to try building something. At that time, H2 was reluctant, saying that he was not very good with computers, but S1 encouraged his participation by saying, "This [Scratch] is for people who are not good at it." (August 24, 2016)

Table 5 presents a situation in which Y1 attempted to pass on the knowledge he had just learned to other members in the process of building Mugbot. As a member who had a relatively better understanding of programming, he wanted to share the knowledge he had gained with other members rather than keeping it to himself. This is a typical occasion of learning through contribution in the group.

Table 5. Excerpt from field notes, July 14, 2016.

Y1 stated that he did not understand an operation using ASCII codes (an expression that reads a string reflecting an input string, i.e., a value entered by the user, one digit at a time and converts it to a number) and asked the author to explain it. The author explained to him the meaning of the formula, and Y1 immediately explained it to S1 and Y2. Y1 generally seemed to understand the behavior of the variable due to the operations in the formula. Then S1 seemed to have understood most of the explanation by Y1 and the author's additional explanation. Y2 did not react well, perhaps because Y2 seemed a little confused. (July 14, 2016)

4.3 Programming As a Proactive Learning Experience Through Trial-and-error Attempts Without Sufficient Information or Knowledge

Programming became a proactive learning experience for the ESDC group due to inevitable trial-and-error attempts. The projects were initiated under an approach of "learn what you need on the fly," and accordingly, the young people had to overcome various challenges without sufficient prior knowledge, which made their programming learning proactive because they had to experiment. The author saw that this situation stimulated the young people's initiative in learning and, in response, stayed out of it as much as possible to watch them learn on their own.

In particular, Y1 showed significant growth in programming skills. Table 6 shows is an excerpt from the field notes on Y1's trial-and-error attempts in the Mugbot production, in which he gradually showed initiative in dealing with garbled characters caused by a misconfiguration of the Raspberry pi.

Table 6. Excerpt from field notes, July 21, 2016.

1:31 p.m. Mugbot production continued. Garbled characters when starting up Raspberry pi. *Coping with Y2 and Y1>> (The author's comments) How far can they go on their own?* *1:33 p.m. S1 said to Y1, "You can see the Raspberry pi setup here [in the book], Chapter 2." S1 also seemed to be able to read the material.* *1:56 p.m. S1, Y1, and Y2 continued to deal with the garbled characters with the author. The author looked up some countermeasures on the Internet and advised Y1 on how to solve the problem, which Y1 then implemented. Y1 was also thinking about the cause on his own: he went back to the initial settings of the Raspberry pi and asked Y2 what settings he had made (or to what extent he had made them). (July 21, 2016)*

Below, Table 7 shows a description of Y1's later growth in digital skills and competencies. Y1 behaved more autonomously in problem-solving.

Table 7. Excerpt from field notes, August 4, 2016 (3).

On the positive side, Y1 found a solution to the Raspberry pi network connection on his own (by running the dhclient command). Here we see Y1's autonomy in problem-solving behavior (he had been searching for the cause of the ssh connection problem with his reasoning since last week when the author was absent) and his expanding knowledge of ICT (enough knowledge to be able to proceed with his research). (August 4, 2016)

4.4 Active Involvement With Programming As the Group's Cultural Identity

The group members came to view their involvement with programming as part of their group identity. After they had accumulated active involvement with programming in various situations, it went beyond personal practice and became a part of the group's culture as a commonly shared practice and value oriented to creativity. For instance, as Table 3 shows, S1 and the youths began to suggest and support the introduction of programming to people who visited the group for reasons such as considering joining. Table 8 depicts a scene in which S1 invited a visitor (H2) to play with Scratch.

Table 8. Excerpt from field notes, August 24, 2016 (4).

H2 was very vocal: "I'm not the best with computers. I'm not very good at using a computer. I'm too busy looking up maps. Programming definitely makes my head dizzy. [Looking at S1's work] It would take me ten years to make something like that." *S1 responded moderately to H2's appeal that he was not good at using computers ("Not good at it? This [Scratch] is for people who aren't good at it, so it's perfect for you...") and encouraged H2 to write some programs in Scratch. Eventually, the instruction to H2 progressed to the point of drawing polygonal*

shapes using repetition while resembling turtle graphics in content. (August 24, 2016)

The group members' involvement in programming was an outcome of their latent culture of creativity. For example, they (especially S1, Y1, and Y2) worked together to introduce programming to group newcomers. Their introduction generally emphasized the pleasure of creation and even the pleasure of discovering oneself capable of creation rather than acquiring practical digital skills. The programming language used was usually Scratch because of the ease of use and its capacity for prompting creative thinking.

5 Discussion

What understanding do the above observations bring about concerning RQ1 and RQ2? Regarding RQ1, collaborative relationships in the ESDC group contributed to the young people's empowerment by (a) providing a rich context in which programming was experienced as discovery-learning-opportunities and (b) helping nurture collaborative agency based on contributions and challenges involved in programming projects. Then, regarding RQ2, the educational significance of programming in the context of ESDC can be found in (c) creating a collaborative membership essential for social participation through contributions to others and (d) developing a cultural basis for participants' human development as actors in a digital society.

Point (a) is based on Finding (1) regarding computer programming's meaning in the ESDC group as a role identity that also encouraged young people's social participation, as well as Finding (3) that trial-and-error attempts made programming a proactive learning experience. The rich context refers to the overall influence that invests participants with both meaning and inevitability of their activities in collaborative relationships with shared responsibility. In the author's observation, such context can generate a mutually supportive role identity among participants, enhancing responsible learning (see [20]). The youths in the ESDC group seemed to learn and challenge themselves because they were responsible members, not isolated individuals. Thus, they contributed to re-create their collaborative relationships within the support group. Further, this role identity allowed them to recognize trials and errors in programming as discovery-learning opportunities even in situations where they lacked sufficient knowledge and information.

Point (b) focuses on empowerment through the nurturing of collaborative agency supported by collaborative relationships in ESDC. This argument is derived from Finding (2) on the acquisition of digital literacy and competencies through voluntary contributions of the members, as well as Finding (3) on the educational aspects of trial-and-error attempts in programming. Collaborative agency in this context refers to the ability to take on roles and responsibilities in a collaborative relationship. The collaborative relationships in the ESDC group helped participants develop collaborative agency in programming projects that necessitated a trial-and-error process and ultimately pushed them toward social participation. The argument comes from the young people's behavior in the support group: At first, they saw themselves as passive learners. However, they eventually overcame programming difficulties by actively

offering what they were good at—a demonstration of collaborative agency. This seemed largely due to their inclusion in collaborative relationships, which gave them the foundation to exercise their independence and supported the autonomous learning necessary for their contributions to the group (see [13]).

Point (c) is derived from Finding (1) on the participants' role identity that added programming as an activity leading to social participation, as well as Finding (2) on the participants' active contributions and resulting learning that drove their digital literacy and competency. Collaborative membership in this argument signifies mutual acknowledgment as members of a programming culture, which gave the participants an identity basis deriving their active contributions. Learning and utilizing programming skills in ESDC projects generated collaborative membership supported by their mutual contribution to the projects. Such membership can be the first step toward social participation, especially among young people seeking support (see [16][20]), and this kind of membership indeed emerged in the ESDC group. For example, Y1, with his relatively advanced programming skills, was acknowledged as a leading contributor by other members, especially when their project reached a critical juncture. Y2, who was not particularly good at programming, was appreciated for his willing contribution in introducing Scratch programming to newcomers.

Point (d) is an assertion concerning programming as a cultural basis of the participants' human development. This assertion is derived from Finding (1) regarding role identity and Finding (4) on the status of programming as part of the group's culture and collaborative relationships. Human development, a term that comes from Sen's capability approach [28], represents the substantiation of physical and cognitive conditions under which people can enjoy their freedom to lead a life worth living. Digital technology as the physical condition of digital society is deemed to disclose its potential to help people's realization of purpose corresponding to their ability to utilize technology.

ESDC, on the other hand, facilitated the youths' adaptation to computer programming, namely, their voluntary participation. Behind the ESDC's facilitation was its inclusion into the programming culture as well as the young peoples' group identities and their continuous efforts that emerged from role identities. They could take programming-related challenges for granted, expanding their digital skills and competencies and thus increasing the probability of benefiting from digital technologies, because their engagement with programming had become part of the group culture.

6 Conclusion and Limitations

The findings of this paper affirm that ESDC characterized by cooperative relationships among participants and projects that require computer programming, is effective as a method of empowerment for young learners. Through the lens of sociological concepts such as role identity and cultural inclusion, the study found the contribution of cooperative relationships in ESDC for empowerment purposes lies in the creation of a rich learning context and cooperative agency with group contribution and responsibility as its core. In contrast, the educational significance of computer programming

based on participants' cooperative relationships exists in these features: First, it provides participants with cooperative memberships that serve as a basis for their social participation. Second, it provides the groundwork for forming a culture that makes it inevitable for the participants to participate in digital society through their involvement in programming. Further hypothetical synthesis of these findings is that the interaction between the projects requiring programming and collaborative relationships among participants in ESDC will work to create a context within which agency and membership, supported by collaboration, will be generated among participants. Besides, the accumulation of their practices creates their own digital culture, and their mutual inclusion in it enables them to participate in the digital society while maintaining collaborative relationships.

It must nonetheless be emphasized that since this qualitative study is based on a small sample, one should be cautious about generalizing the research results. The findings must be read critically, especially in light of sociocultural factors, diffusion of digital technologies, and educational circumstances surrounding digital skills and competencies.

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