Master's Programme in Global Development and Planning – Development Management specialisation

MASTER'S THESIS

TITLE:

The role of automated feedback in learning to program - Puzzle pieces of ICT-supported education for sustainability.

Keywords: Online Learning for Sustainability, Help-seeking online, Learning Technologies, Feedback for Learning.

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Abstract

Education in remote areas is widely discussed nowadays. It became an even greater topic when the pandemic has happened and the UN's Sustainable Development Goals have stated that education has to be open and accessible. To support a diverse population online and remote learning is utilized. There are many factors that impact learning while feedback is an essential component to facilitate learning. It helps to create a dynamic, motivating and engaging learning environment. However, different people are using help in the form of feedback in various ways.

To support the diverse population to learn programming online this study explores the topic of help-seeking and feedback in learning. The two groups of research questions addressed 'how' people use feedback and 'what' impacts help-seeking and feedback usage when learning programming online.

The central finding of the study suggests that close attention to the *timing of feedback provision* on learning platforms has to be given. The factors such as prior learner experience, learning goals and presents of time restriction impact on when feedback should be provided and whether it will be used by learners.

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Chapter 1

Introduction

"The future of education lies in innovation"

— Ms Sarah Brown, founder of children's charity Theirworld and Executive Chair of the Global Business Coalition for Education.

Background

Education in remote areas

Education is one of the topics addressed in the UN's Sustainable Development Goals. Following the Covid-19 pandemic, special emphasis was placed on accessibility and inclusion of education, especially in remote regions. To ensure that young adults are prepared for the future and can compete on a global scale, education should be provided in the most relevant areas. According to the "Jobs of Tomorrow" report from the World Economic Forum (2020), two of the seven key professional clusters where the most emerging professions are located are in Data & AI and Engineering. The report emphasizes skills in development tools, web development, software development as skills for learning to acquire professions in Data and Engineering (World Economic Forum, 2020).

Programming education in remote areas - success stories

Many programs led by companies and nonprofit organizations provide technical training in remote areas. Examples include the Information and communications technology (ICT) for Youth Employability and TechKids ICT programs in Uganda, the “Coding for Employment” program led by the African Development Bank in Kenya, Rwanda, Senegal, and Nigeria, Rockefeller Foundation, Microsoft, and Facebook. All of the programs have shown successful outcomes.

The “Coding for Employment” digital training was launched in 2018 with the aim to prepare African youth for future jobs by providing them training in ICT skills alongside other skills (African Development Bank Group, 2020). As of today, over 23,000 youth completed the month-long courses provided by the “Coding for Employment” program (African Development Bank Group, 2020). One of the participants, Odetola Olashile Oluwapelumi, responds with the following about the program:

"*The training has been beneficial to me," Oluwapelumi says. "As a nursing mother…[being] able to work online from home…has helped me to be able to support the family*" (African Development Bank Group, 2020).

Another success story of bringing programming to remote areas is the "Turning disadvantaged Youth into IT Developers in Uganda" pilot program, which was initialized in 2019 by Plan International Norway and implemented by Diggit AS and SmartUp Factory. The main aim of the pilot was to train 14 young adults in web design and programming skills. According to CEO of Diggit AS, Magnus Lysfjord, "80% of the program participants gave 10 out of 10 on the question of how useful it is for their future to acquire skills in web design and programming[1]. Nine participants of the program have also expressed their willingness to be instructors and pass their ICT knowledge down" (Lysfjord M., November, 2020). Lysfjord also quoted one of the graduates of the program:

"*One of the graduates currently works as a volunteer who runs youth mentorship at Smartup Factory in Uganda, sometimes he also takes on some freelance projects from friends, and these facilitate his survival (rent and other personal needs). The graduate said he is passionate about web development, mobile development, and changing the lives of young people. He is currently working on improving his skills so that he can have the chance to work professionally. His ambition is to one day work with the creative products that will make a better tomorrow and also reach as many passionate young people as he can reach to create an impact on life through software*" (Lysfjord M., November, 2020).

Bringing programming education to remote regions can affect the employment rate, gender issues, and therefore increase the livelihoods of local communities and individuals, as illustrated in the previously mentioned examples. However, there are diminishing resources for education in remote areas, and due to the limited number of teachers providing high quality and personalized learning becomes a challenge (Chetwynd & Dobbyn, 2011). It is especially notable in the programming context where students submit their assignments very frequently and the correctness of solutions is harder to define (Rivers, 2017; Blayney & Freeman, 2004). Online and distance education can address these issues. While being highly accessible and in a lot of

[1] The other three participants gave it 7, 8 and 9

cases open, online and distance learning also contributes to sustainability (Simpson, 2012; Roy, Potter & Yarrow, 2008). From teaching and learning perspectives, online learning tools make the learning process more dynamic and interactive (Carless et al., 2011; Chetwynd & Dobbyn, 2011, Mory, 2004). One of the participants in the study put it well in words: “In online learning platforms, you are exposed to a bunch of useful examples of solutions while trying to resolve a programming problem, this way you start to see patterns. It is easier and much more engaging to learn programming concepts that way than to read a dry book that is a thousand pages long” (Study participant, August 27, 2020).

Feedback to address challenges in learning online

While learning is supported by various processes, feedback is considered one of the most effective ways to enhance learning in general (Hattie & Timperley, 2007; Askew & Lodge, 2004) and online learning (Ross, Jordan, & Butcher, 2006). In the literature, feedback is defined as "information with which a learner can confirm, add to, overwrite, tune, or restructure information in memory" (Winne & Butler, 1995, p. 275). A wide number of research supports that feedback has influence on academic achievements, learners engagement, and quality of learning process (Zhang & Hyland, 2018; Hattie, 2009; Shute, 2008; Hounsell, 2007). According to Hattie (2009) feedback “fell in the top 5 to 10 highest influences on achievement in Hattie’s (1999) synthesis” (p. 83).

Although research shows that feedback contributes to learning and addresses both immediate and lifelong learning goals (Mackinnon et al., 2016; Hounsell, 2007), it can only perform these functions if it is of high quality, sustainable, and given in a timely manner (Carless, et al., 2011; Hounsell, 2007). Giving such feedback in large quantities costs academics at a high price (Blayney & Freeman, 2004), which is especially remarkable in remote regions. Technology-supported feedback can address this challenge (Mory, 2004), particularly automated feedback for learning has been discussed wildly in the literature (Prather et al., 2018, Zhang & Hyland, 2018, Rivers, 2017, Carless et al., 2011, Ross, Jordan, Butcher, 2006, Douce, Livingstone & Orwell, 2005; Blayney & Freeman, 2004). Studies on education and

human-computer interaction find that there are many benefits to using automated feedback. Automated feedback increases the interactivity aspect of learning, provides help "just in time" and reduces learners' frustration (Carless et al., 2011; Debuse et al., 2008; Justin, Meredith & Rania, 2008). It also ensures students' autonomy and thus facilitates self-regulated learning processes (Zhang & Hyland, 2018). When it comes to experience with feedback, the recent studies show that students prefer automated feedback over manual feedback (Zhang & Hyland, 2018; Carless et al., 2011; Pears, Seidman, Malmi, Mannila, Adams, Bennedsen, Devlin & Paterson, 2007). Research shows that automated feedback is especially useful when learning programming (domain with open-ended problem solving) where high frequency feedback is needed and it is harder to define correctness of learners solutions (Ott, 2015; Pears et al., 2007; Rivers, 2017; Blayney & Freeman, 2004).

But even when good feedback is provided "the crux of the matter is how students interpret and use feedback" (Carless et al., 2011, p. 2). Different learners have different ways for seeking help online and using automated feedback. The current literature on help-seeking shows that learner-related factors, factors related to learning goals, strategies, help-seeking attitudes are impacting on desire to seek help in general context (Qayyum, 2018; Ryan, Patrick & Serena, 2005; Zarrin & Paixão, 2016; Newman & Schwager, 1995). Factors such as problem difficulty, "learning proficiency level, academic performance, and epistemological belief" impact on learners' desire to seek help online (Hao et al., 2016, p. 471). When it comes to feedback usage, factors such as feedback design and learners' individual factors affect how learners use feedback (Rivers, 2018, Hattie & Timperley, 2007).

In the literature, one can see patterns in how people use automated feedback when learning to program, particularly what factors impact their willingness to use it and how they experience automated feedback. Many studies mention feedback design as a crucial factor for its use (Rivers, 2017;Hattie & Timperley, 2007). Timing is one of the factors frequently mentioned in the feedback design literature (Zhu, Liu & Lee, 2020; Aleven et al., 2016; Carless, et al., 2011; Shute, 2008; Hattie & Timperley, 2007; Blayney & Freeman, 2004). Some learners use feedback before they get stuck (immediate feedback) while others prefer to wait (on-demand feedback) (Rivers, 2017; Corbett & Anderson, 2001). Learner-related factors are also highly emphasized in the literature. These factors involve the learner's previous experiences with the use of automated

feedback, prior knowledge and experience with programming (Zhang & Hyland, 2018; Esterhazy, 2018; Zarrin & Paixão, 2016).

Research problem and question

Although help-seeking online and automated feedback in learning is widely studied - it does not provide a sufficient overview of how learners use automated feedback in learning to program online. To support a diverse population through providing learning in remote areas more research is needed in how learners use automated feedback. More research is needed in how learners seek help online, how feedback is perceived and utilized by learners, and how learners report automated feedback being useful for their learning (Hao et al., 2016; Melanie, 2006; Mory, 2004). Qian and Lehman (2019) and Rivers (2017) argue that more research is needed to examine forms of automated feedback to make it beneficial to learning. Mory (2004) also emphasizes that future research in how feedback is used in problem-solving domains (such as programming) is needed. The current study focuses on the problem of insufficient knowledge about how online help-seeking happens and how automated feedback is used by learners in online or distance learning.

Bringing more knowledge to the topic will facilitate the design and development of a better environment for learning to program online and remotely. Therefore, it is important to study help-seeking online, automated feedback usage when they learn to program online, factors influencing feedback usage, and students' experience of this way of learning. Therefore, the main research question is formulated as follows:

How do people use automated feedback when learning to program online?

The secondary research questions are formulated as follows

1. How do people perceive help-seeking online?
2. What is the experience of using automatic feedback when solving programming problems reported by participants?

3. What factors impact feedback usage when learning to program?

Although there are a lot of factors that facilitate learning to program online, providing help and automated feedback are seen as one of the central elements to benefit learning processes (Hattie & Timperley, 2007; Hounsell, 2007; Ross, Jordan, & Butcher, 2006; Weaver, 2006; Askew & Lodge, 2004; Blayney & Freeman, 2004). Automated feedback also facilitates self-regulated learning which is especially important when learning programming alone through online platforms (Zhang & Hyland, 2018). Automated feedback also facilitates teachers by helping them to provide more frequent feedback to the learners exactly when they need it (Chetwynd & Dobbyn, 2011). But it is not clear how automated feedback is used by learners during their process of learning programming online. Therefore, it is necessary to study help-seeking and automated feedback to support the design and development of learning environments for learning to program online.

The purpose of this study

The aim of this study is to explore how people seek help online and automated feedback usage in learning to program online and distance. Qualitative methodological approach was taken to reach the study objectives. The data was collected using primary sources by conducting interviews and observations on samples of young adults living in Oslo, Norway. The data collected from the interviews will support the understanding of the participants' perception of help-seeking online. It will also be supportive in gaining insight into the factors that affect the use of feedback based on the participants' previous experience. The observations will imply participants' observations while they solve a practice problem and observation of the screen recorded during the practice problem. The data collected from the observations will help to understand the participants' experience with the use of automated feedback when solving programming problems.

Benefits of this study

By analysing the participants' perception on help-seeking online and the use of automated feedback when learning to program, this study can facilitate the design and development of more effective learning environments. It will bring more empirical evidence for their design choices. The findings of this study will also benefit educators (e.g., teachers and programming instructors) seeking to improve the quality of the learning process by providing more tailored feedback that "fits for the purpose" (David, Diane, Min & Joy, 2011, p. 395). By making higher quality feedback that is timely, sustainable will increase the quality of learning by supporting students to reach immediate goals and facilitate them in the long run. Such automated feedback can also help in becoming self-regulated, autonomous learners which is especially relevant for remote education in developing countries where there is a limit in academic resources (Zhang & Hyland, 2018; Chetwynd & Dobbyn, 2011). This study will also benefit the researchers, students and individuals that are interested in exploring the power of feedback with particular focus on the use of automated feedback in learning to program.

Structure of the thesis

This thesis begins with proving an extended review of related literature. The research on help-seeking, feedback in learning and the factors that influence the use of automated feedback in learning programming will be presented. Then the methodological approach used to collect and analyze a sample of data sets. The findings, discussion and recommendations are then presented. This thesis concludes by providing a potential direction for future research on automated feedback in learning to program online.

Chapter 2

Literature review

“You are not looking for a solution. You're just looking for a hint, where you start” (Participant B, Interview, August 2020)..

Introduction

The need to facilitate online and distance learning of programming has increased in recent decades due to the flexibility it provides teachers and learners, and because it is accessible from remote areas where resources for education are very diminishing (Chetwynd & Dobbyn, 2011; Blayney & Freeman, 2004). There are many target groups that can benefit from online learning and from understanding how distance learning to program happens. While learning is supported by different processes, feedback is considered one of the most efficacious in enhancing learning and is seen as central to learning and high achievement (Hattie & Timperley, 2007; Hounsell, 2007; Askew & Lodge, 2004; Blayney & Freeman, 2004).

Research shows that feedback is helpful and effective when its types and forms are matched correctly to individual learners (Grawemeyer, Mavrikis, Holmes, Hansen, Loibl & Gutierrez-Santos, 2015; Narciss, Huth & Narciss, 2002); however, learners have different ways of seeking help online and using feedback. This can be influenced by various factors including: individual (learners), social, cultural, gender, ethnicity, demographic factors (Zarrin & Paixão, 2016; Ogan & Walker & Baker & Rodrigo & Soriano & Castro, 2014; Williams & Takaku, 2011; Karabenick & Newman, 2006; Ryan & Patrick & Serena, 2005; Askew & Lodge, 2004; Newman, 2002; Conrad & Goldstein, 1999). In order to support a diverse population to seek help online and use automated feedback in their process of learning to program, there is a need to first understand what the literature has found until now about these topics and about various factors that influence these processes.

This literature review examines the importance of seeking help and automated feedback to strengthen the process of learning to program online. This review begins with a brief introduction to the reader of how the notion of seeking help was involved in research over time and how help-seeking happens online. Findings on factors that influence help-seeking and types of help-seeking behavior are then presented. The review then moves on to the topic of feedback in learning by placing special emphasis on what is an effective feedback, feedback types and forms. Research on technology-supported feedback and automated feedback as a form of is presented afterwards. Finally, the factors that influence the use of automated feedback in

learning to program are illustrated. The literature review concludes by identifying the problems and knowledge gaps in help-seeking online and automated feedback for learning to program.

Help-seeking

Definition

Research in help-seeking has a long history back, where the pioneering work by Sharon Nelson-Le Gall should be especially emphasized. Back then, help-seeking was seen as an "index of dependence in the early studies of socialization and personality development" (Gall, 1985, p. 56). Although help-seeking was recognized as beneficial and necessary, it was then characterized as degrading activity to be avoided (Beller, 1955; Gall, 1985). The research then described the physiological risk and embarrassment associated with asking for help (Gall, 1985). Back then research has not viewed that there is correlation in between help-seeking and academic performance (Newman, & Schwager, 1995). These views were undertaken by later research in social and educational psychology, and instead of degrading help-seeking, the research now focuses on understanding behavior patterns and attitudes towards help-seeking (Zarrin, Paixão, 2016; Williams, Takaku, 2011; Villavicencio, 2011; Karabenick & Newman, 2006; Ryan, Patrick & Serena, 2005; Karabenick, 2003). Recent studies view help-seeking not as weakness but as an important aspect of learning strategy that impacts on students' achievement and performance (Karabenick & Newman, 2006). Karabenick & Berger (2013) define help-seeking as "the process of seeking assistance from other individuals or other sources that facilitate accomplishing desired goals, which in an academic context may consist of completing assignments or satisfactory test performance" (Karabenick & Berger, 2013, p. 238). Zarrin and Paixão (2016) support the notion and add that help-seeking is about reaching mastery and finding clues to achieving success (Zarrin & Paixão, 2016).

This section provided a brief historical background on help-seeking research. In the next section, the factors that influence help-seeking will be introduced.

Factors that impact help-seeking

Some students tend to actively seek help when facing an academic challenge while others are resilient and avoid help-seeking. This behavior is important to understand because help-seeking behavior has a strong correlation with students' academic performance (Black & Allen, 2018; Williams & Takaku, 2011; Karabenick & Newman, 2006; Ryan, Patrick & Serena, 2005; Butler, 1998; Newman & Schwager, 1995). Help-seeking has also a strong connection with students' achievement goals (Zarrin & Paixão, 2016; Karabenick & Newman, 2006; Karabenick, 2003; Newman & Schwager, 1995). Among other benefits, help-seeking can support students to avoid potential mistakes, maintain engagement, increase the chance of long-term mastery and independent learning (Newman, 2002).

This section presents factors related to individual characteristics of learners that are impacting on help-seeking behavior: achievement goal orientation and help-seeking attitudes. Help-seeking research also distinguishes the following factors that are not presented in this section but will be partly illustrated in the review later on. These factors are: learner-related factors (age, gender, self-esteem, prior knowledge of the subject domain), learning strategies, attributes of the help-seeking environment (affective experiences in the classroom), relationships with teachers, academic efficacy, task value, students' grade level (Qayyum, 2018; Ryan, Patrick & Serena, 2005; Zarrin & Paixão, 2016; Newman & Schwager, 1995).

Achievement goal orientation

Achievement goal orientation is important for understanding help-seeking behavioral tendencies. Research distinguishes four types of achievement goals: mastery approach, mastery avoidance, performance approach, and performance-avoidance (Zarrin & Paixão, 2016; Karabenick, S., Newman, R. S., 2006; Ryan, Patrick & Serena, 2005). Number of studies have analyzed the relationship between help-seeking behavior and the type of achievement goal orientation students have (Zarrin & Paixão, 2016; Karabenick & Newman, 2006; Karabenick, 2003; Newman & Schwager, 1995). Zarrin and Paixão (2016) found that there is a positive correlation

between willingness to seek help and mastery approach goals, which was also confirmed in previous research on help-seeking (Ryan, Patrick & Serena, 2005; Karabenick, 2003).

Learners oriented on mastery goals are likely to consider using help to achieve their academic goals, and they view help-seeking as a positive factor for their learning (Zarrin & Paixão, 2016). Expanding the argument Karabenick (2003) found that the mastery goal is directly related to instrumental help-seeking and preference for formal sources of assistance. When looking closely at the differences in behavior between mastery approach and mastery avoidance orientations, research shows that learners with mastery approach goals concentrate on learning, gaining understanding, advancing their skills, achieving insight (Zarrin & Paixão, 2016; Ryan, Patrick & Serena, 2005), while learners with mastery avoidance goals avoid not mastering a task, misunderstanding, or making mistakes (Zarrin & Paixão, 2016).

Learners with performance-approach and performance-avoidance strategies seek help differently. The ones with performance-approach goals are concerned about being evaluated positively by their peers, compare themself using social comparison criteria and avoid asking for help to minimize the effort (Zarrin & Paixão, 2016; Ryan, Patrick & Serena, 2005; Karabenick, 2003). Those with the performance-avoidance deem consider asking for help as a sign of inability, they are afraid of being seen as a failure and generally have a low level of motivation (Zarrin & Paixão, 2016; Karabenick, 2003).

Help-seeking attitudes

Help-seeking attitudes (referred to as concerns in some literature) are another factor that affect help-seeking behavior. Research distinguishes three general attitudes that learners have about help-seeking: autonomy, ability, expedient concerns (Ryan, Patrick & Serena, 2005). Students with autonomy concerns desire to be independent and, therefore resistant to help-seeking (Price, Dong, & Lipovac, 2017; Ryan, Patrick & Serena, 2005). The same concluded by Felicidad T. (2011) in the statement that students who are "highly effective, do not necessitate help-seeking", in other words, students resist help because they believe in their own ability to complete tasks alone.

Ability concerns are related to learners being worried about looking stupid if they ask for help, and therefore they are likely to hesitate or avoid help-seeking in the first place (Qayyum, 2018; Ryan, Patrick & Serena, 2005; Karabenick, 2003). Research does not provide answers to what is the basis for this kind of help-seeking threatening behavior (Karabenick, 2003); however, current studies show that learners are less afraid to ask for help in the digital space (Qayyum, 2018).

Learners with expedient concerts believe that help will not be effective and therefore avoid asking for help at first place (Ryan, Patrick & Serena, 2005). These students may be concerned about the availability of help, the lack of competent assistants and how long it takes to get help (Ryan, Patrick & Serena, 2005; Price, Dong & Lipovac, 2017). The quality of help is also a factor that students with expedient attitudes may be concerned about, and as a result, if they have experienced low-quality help, they are less likely to ask for additional assistants, even if they are struggling with a task (Price, Dong & Lipovac, 2017). But if they were to ask for help, they would seek dependent (also referred as executive in some literature) help, in other words, ask for a direct answer to their question (Karabenick, 2003; Ryan, Patrick & Serena, 2005).

Types of help-seeking behavior

Types of help-seeking are closely related to the factors that impact on help-seeking that were described earlier. In this section, the two views on categories of learners based on their help-seeking behavior are presented. First, the view presented by Karabenick (2003) is illustrated. The author distinguishes Strategic / Adaptive Formal, Strategic / Adaptive Informal, Non-Strategic and Avoidant types of help-seeking behavior. Then the findings from the later study by Ryan, Patrick and Serena (2005) are presented. The authors defer appropriate, avoidant, and dependent help-seeking behavior. There were no contradictions found in the way the authors categorise the types of help-seeking behavior but the basis for the characterization is different.

Karabenick (2003) distinguishes four groups of help-seeking behaviors based on the indicators such as students' motivation, achievement goal orientation, learning strategies and performance. The first one is Strategic / Adaptive Formal group. The learners with this type of help-seeking behavior are highly motivated, self-regulated, strategic, and adaptive. This group shows a relatively high level of using instrumental help, low levels of help avoidance and help threat

(Karabenick, 2003). They seek high-quality help, and utilize available resources to achieve learning objectives (Karabenick, 2003). The second group is learners with Strategic / Adaptive Informal help-seeking behavior. This group is sharing most of the characteristics with the first group but tends to ask for help from their peers (other students) instead of their teachers / instructors. This group is characterized as those who seek help to avoid work (Karabenick, 2003). The third, Non-Strategic group has a higher level of executive help-seeking and lower level of formal help-seeking in comparison with the group one and two (Karabenick, 2003). The students in this group are comparatively non-strategic, non-adaptive and show low-performance levels (Karabenick, 2003). The last group of help-seeking behavior is Avoidant. Significantly high level of help-seeking threat, avoidance, and executive goals clearly distinguishes the fourth group from the rest (Karabenick, 2003). At the same time, this group of students have moderately high instrumental-formal help-seeking orientation, as well as moderately high levels of motivation and strategy use (Karabenick, 2003).

The later study on help-seeking tendencies (Ryan, Patrick & Serena, 2005) distinguishes three types of help-seeking behavioral tendencies based on help-seeking attitudes, achievement goal orientation, affective experiences, relationships with teachers, efficacy, fifth- and seventh-grade achievement (Ryan, Patrick & Serena, 2005). The authors of this view highlight the following types of help-seeking: appropriate, avoidant, and dependent. Appropriate defined as a type of help-seeking behavior in which students ask for help when they need it and are not dependent on asking for help the moment they face challenges (Ryan, Patrick & Serena, 2005). Avoidant help-seeking can be characterized as oriented towards performance-avoidance goals, which means avoiding asking for help so as not to be seen as a failure or assuming that help will not provide with useful information (Zarrin, Paixão, 2016; Ryan, Patrick & Serena, 2005). It was also found that avoiders have "low levels of emotional support and social efficacy with teachers" and generally low levels of motivation (Zarrin, Paixão, 2016; Ryan, Patrick & Serena, 2005). Students with dependent help-seeking behavior are characterized as those who seek help at a time when they experience difficulties and do not persist in independence (Ryan, Patrick & Serena, 2005). It was also found that dependent on help-seeking students tend to be in “the middle of the pack regarding achievement, did not feel particularly efficacious in terms of their

capabilities, experienced anxiety over their performance" (Ryan, Patrick & Serena, 2005, p. 283).

Help-seeking online

Technology-assisted learning has opened up new opportunities for seeking help online. The questions of seeking help in the digital space have been raised in studies by many authors: Cheng, Liang, Tsai (2013); Lee, Chiu, Liang, and Tsai (2014); Hao, Wright, Barnes, Branch (2016); Chyr, Shen, Chiang, Lin, Tsai (2017); Qayyum (2018). Online help-seeking is referred to as help search supported by online tools, some authors include the following activities under online search help: online search, asking teachers or peers for help online (Hao et al., 2016).

There are many benefits to learning when seeking help online rather than using traditional help-seeking methods. During the study conducted by Chyr et al., (2017), it was found that students' engagement, self-efficacy, self-directed learning improved over time with the intervention of online academic help-seeking. When it comes to students' experience, some studies found that students prefer to use digital technology over traditional teaching methods to ask for help (Qayyum, 2018; Chyr et al., 2017). Furthermore, students experience a higher threat in traditional classes than students in distributed classes or distance learning courses where help seeking online happens (Qayyum, 2018). At the same time, when it comes to students' use and engagement with online help-seeking, it was found that students with higher performance are more likely to seek help online (Hao et al., 2016). Where the following factors influence learners' willingness to seek help: problem difficulty, "learning proficiency level, academic performance, and epistemo-logical belief" (Hao et al., 2016, p. 471).

Feedback in learning

This section introduces the notion of feedback in learning and views on feedback by different studies, types of feedback and what is considered effective and sustainable feedback. Then

feedback forms are presented with special emphasis on automated feedback, hints as a form of automated feedback and automated feedback types.

Definition

Research provides a range of views on feedback. In the early literature, feedback is defined as "information with which a learner can confirm, add to, overwrite, tune, or restructure information in memory, whether that information is domain knowledge, meta-cognitive knowledge, beliefs about self and tasks, or cognitive tactics and strategies" (Winne & Butler, 1995, p. 275). According to Hattie and Timperley (2007), feedback is “information provided by an agent (e.g. teacher, peer, book, parent, self, experience) regarding aspects of one’s performance or understanding”. Taylor and Silva (2014) define feedback in a broader perspective as “a mechanism to support learning, whether formally or informally, in either a formative or summative manner” (p. 796).

Feedback is an essential tool to support students and teachers in learning (Meerah & Halim, 2011; Justin, Meredith & Rania, 2008; Hattie & Timperley, 2007; Blayney & Freeman, 2004; Askew & Lodge, 2004). Feedback “guide students toward more efficate engagement in learning activities” (Butler & Winne, 1995, p. 265). Some studies report that feedback has a non-facilitative effect on learning (Kluger & DeNisi, 1996). Bruno and Santos (2010) refer to Black and Wiliam (1998) who "reported that in 40% of 131 studies feedback had a negative impact on students’ performance" (p. 112). Recent research, however, found that feedback has a positive impact on learning and academic performance when both the type and the way feedback is provided are correct (Hattie & Timperley, 2007).

Feedback types

Research distinguishes two main types of feedback: formative and summative (Taylor & Silva, 2014; Bruno & Santos, 2010; Birenbaum et al., 2006; Ross, Jordan & Butcher, 2006; Winne & Butler, 1995). Formative feedback can be defined as feedback that aims to improve students' performance and contributes to the progression and acceleration of learning (Taylor & Silva,

2014; Bruno & Santos, 2010; Ross, Jordan & Butcher, 2006). Formative feedback is usually presented as a response to some actions on the learner's part (Shute, 2008). Shute (2008) defines formative feedback as " information communicated to the learner that is intended to modify his or her thinking or behavior to improve learning" (p. 153). Birenbaum et al. (2006) characterizes formative feedback as the one that is "integrated into the curriculum, authentic, context embedded and flexible" (p. 62). Formative feedback can be provided in different forms e.g. hints, worked-examples, automated feedback (Shute, 2008). Timing of formative feedback can be immediately delivered or on-demand feedback (Shute, 2008). In the contract, summative feedback can be described as feedback that is "unauthentic, context-independent, inflexible and uneconomical" (Birenbaum et al., 2006, p. 62). Summative feedback is intended to judge students' performance and does not support students in developing knowledge and competency (Bruno & Santos, 2010; Weaver, 2006). The current study focuses on formative feedback, feedback that provides suggestions on how to improve students' work and actually has an effect on the learning process.

Good feedback practice

Focus on effectiveness

The properties necessary for feedback to be effective have been widely discussed (Chetwynd & Dobbyn, 2011; Hattie & Timperley, 2007). Effective feedback should address the three main questions by learners or teachers: "Where am I going? How am I going? Where to next?" (Hattie & Timperley, 2007, p. 86). The first question: "Where am I going?" or "What are the goals?" corresponds to the feedback function to provide information on the achievement of learning objectives with regard to the task or learning performance (Hattie & Timperley, 2007). Feedback related to goals is considered effective feedback while feedback consists of praise, punishment, and external awards does not facilitate learning (Hattie & Timperley, 2007). The question: "How am I going?" or "What progress is being made towards the goal?" is about giving the direction of the feedback in relation to a task or performance (Hattie & Timperley, 2007). The feedback that provides information about correct rather than incorrect answers, and when it is based on

changes from previous attempts have been shown to be more effective (Hattie & Timperley, 2007). The last question on “Where to next?” or “What activities need to be undertaken to make better progress?” corresponds to providing information on progress and how to proceed (Hattie & Timperley, 2007).

Focus on sustainability

The notion of "sustainability" is not well represented in research related to learning; when mentioned, sustainability in learning refers to lifelong learning (Mackinnon, Pasfield-Neofitou, Manns & Grant, 2016). Sustainability in the context of assessment was first mentioned by Boud (2000). The author supports the view of providing sustainable assessment to enrich learning throughout life Boud (2000) and emphasize that assessment “has to do double duty”: “meet the specific and immediate goals of a course as well as establishing a basis for students to undertake their own assessment activities in the future” (Boud, 2000, p. 151). Boud (2000) justifies the use of the term sustainable assessment due to its resonance with sustainable development. In the Brundtland Commission (Brundtland, 1987), sustainable development was defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. Based on the definition, Boud (2000) defined sustainable assessment as an assessment that corresponds to the students' current needs, at the same time as it prepares them to undertake future learning needs.

What does the notion of sustainability mean in the context of feedback? Hounsell (2007) first introduces the notion of sustainable feedback based on the definition of sustainable assessment developed by Boud (2000). Sustainability of feedback refers to a feedback function that enriches students to potential lifelong learning and facilitates learning beyond the task feedback applies (Hounsell, 2007). In the later study by Carless (2011), the sustainable feedback concept was defined as “dialogic processes and activities which can support and inform the student on the current task, whilst also developing the ability to self-regulate performance on future tasks” (Carless, et al., 2011, p. 397). Under the term “dialogic” the authors mean an interactive process between the receiver (learner) and the giver (instructor) of feedback (Carless, et al., 2011; Askew & Lodge, 2004). In some literature, "dialogue" is also referred to as a "ping pong" process (Askew & Lodge, 2004). The importance of ability of formative feedback to facilitate

self-regulated learning in order to be effective is also supported by Parr and Timperley (2010). When characterizing sustainable feedback, Carless, et al. (2011) refer to the seven principles of good feedback practice presented by Nicol and Macfarlane-Dick (2006). The two most relevant principles for sustainable feedback are "that it facilitates the development of self assessment and reflection in learning, and encourages teacher and peer dialogue about learning" (Carless, et al., 2011, p. 397). Although feedback is one of the most important influences of learning processes, based on the type of feedback and the way it is given, it can lead to different effects (Hattie & Timperley, 2007; Grawemeyer et al., 2015). In the next subsection, the different types of feedback will be presented.

Feedback forms

It is important to provide the preferred form of feedback in learning processes. Studies show that providing a non-preferred form of feedback has a significant effect on learning (Taylor & Silva, 2014, Bower, 2005). Taylor and Silva (2014) study found that there is significant variation in what form of feedback is needed to support learning for diverse populations.

This section presents an overview of different feedback forms that research distinguishes. The regular types of feedback such as written, verbal feedback and dialogue are presented first. Then the current research on technology-supported feedback is illustrated with special focus on automated feedback. The literature on feedback also distinguishes peer feedback, textual, video forms of feedback for learning that are not presented in this section (Hsia, Huang & Hwang, 2016, Bijami, Kashef & Sharafinejad, 2013, Gielen, Peeters, Dochy, Onghena & Struyven, 2010, Lalley, 1998).

Regular feedback

Written feedback

Written comments is one way of providing feedback. Several studies point to benefits of written feedback for learning and teaching (Weaver, 2006, Bruno & Santos, 2010, Stracke & Kumar,

2010) and to the fact that the teachers and learners find it helpful and desirable (Goldstein, 2004). Yang and Carless (2013) found that learners prefer written feedback over the verbal one as it is not always easy to recognize verbal feedback in a conversation.

Some studies, however, point out that written feedback is demanding and time-consuming to create while learners do not view it as useful as teachers do (Price, Handley, Millar & Donovan, 2010, Maclellan, 2001). Written comments are often short while, as Walker (2009) points, they have to "convey a lot of great deal in a few words" (p. 68). Success of written feedback depends on teachers' knowledge of the skills and personality of each learner and therefore creating a written feedback becomes a difficult and complex process (Bruno & Santos, 2010). As Chanock (2000) concludes, making written comments should be done carefully and examples from lectures and reading should be provided in order to facilitate learning, otherwise it can become too deeply encrypted (Yang & Carless, 2013).

Verbal feedback & Dialog

Verbal feedback and dialogue is another form of feedback in learning. The aim of verbal feedback is to provide learning benefits through interaction between teachers and learners (Kerr, 2017) it also aims to clarify confusions when a learner needs it (Yang & Carless, 2013). Learners view verbal comments as "underpinned by a journey towards clarity, thus feeding forwards" (Kerr, 2017, p. 458). Porte, Xeroulis, Reznick & Dubrowski (2007) conducted a study on medical students in which they gave different groups of students different forms of feedback: computer-generated feedback on the economics of their movements, "motion economy feedback" and verbal feedback (Porte et al., 2007). The study showed that the group that received verbal feedback showed retention of skill on delayed performance testing (Porte et al., 2007). Thus, the authors concluded that verbal feedback has a long-term effect on improving technical skills (Porte et al., 2007). Carroll (1995) points to the fact that verbal feedback (either explicit or implicit) can be challenging to interpret due to its complexity. To support interpretation of verbal feedback it is facilitated by dialog (Kerr, 2017, Howe & Abedin 2013). However, recognizing verbal feedback from normal dialogues can be difficult for students, and

factors such as emotions, expectations and atmosphere affect how students receive this type of feedback (Kerr, 2017).

Technology-supported feedback

In the previous section written and verbal feedback were discussed. It is shown to benefit learning; however, research shows that feedback supported by technology is more effective and more suitable for online and distance learning (Sheard, 2011; Carless et al., 2011; Chetwynd & Dobbyn, 2011; Race, 2005). The interactivity aspect and the ability to provide feedback "just in time" were mentioned among the benefits of technology-supported feedback (Carless et al., 2011) . While technology-based feedback promotes student autonomy and decreases the amount of teachers involvement which is beneficial for online and distance (Carless, et al., 2011), there are also some downfalls in this form of feedback. Particularly if feedback on a technology-based environment is always available for learners it can become "spoon feeding" (Carless, et al., 2011, p. 402). Thus in order for feedback to be sustainable and facilitate learning it has to be timely and provided only when learners need it (Carless et al., 2011). The questions of feedback provision timing will be discussed in the later sections. Another downfall is that even after considerable design effort, technology-supported feedback does not allow learners to demonstrate collaborative and communicative skills (Blayney & Freeman, 2004).

Automated feedback

Automated feedback is one of the types of technology-supported feedback. It has been widely studied by researchers in human-computer interaction, computer-based education and other fields (Prather et al., 2018, Zhang & Hyland, 2018, Rivers, 2017, Carless et al., 2011, Ross, Jordan, Butcher, 2006, Douce, Livingstone & Orwell, 2005). Research shows that automated feedback has a lot of benefits over regular (manual) feedback (Zhang & Hyland, 2018, Debuse, Lawley, & Shibl, 2008). It helps learners to get an immediate answer to their questions, reduce frustration and support in solving assignments faster. At the same time it also benefits educators by saving their time by improved workflow and increases the quality of the learning process in general by making it more interactive and dynamic which is especially beneficial when it comes to online and distance learning and teaching (Carless et al., 2011, Debuse et al., 2008, Justin et

al., 2008). Building on this, Zhang and Hyland (2018) found that "automated writing evaluation feedback has discernible advantages over teacher feedback in terms of timeliness, convenience, multiple drafting, and even potential learner autonomy" (p. 100). The authors note that the students in the study sought immediate feedback on the writing and participated in the review process while the problem is still in their minds (Zhang & Hyland, 2018). As Ross, Jordan and Butcher (2006) puts it crispy automated feedback is a tutor at learners elbow.

Automated feedback for learning to program

Research shows that automated feedback can be especially beneficial for learning programming where one of the core activities is problem solving (Ott, 2015, Pears et al., 2007, Blayney & Freeman, 2004). Because of the nature of programming activities it is important to provide instant assistance to facilitate learners' progression and reduce frustration (Rivers, 2017, Ott, 2015). Traditionally automated feedback is provided through Intelligent Tutoring Systems (ITS) in form of correctness feedback, error-specific feedback, and next-step hints (Rivers, 2017). The Correctness feedback aims to simply communicate to learners if their solution is right or wrong (Rivers, 2017). Error-specific feedback points to an incorrect part of learners' solution (Rivers, 2017). Lastly, the next-step hints guide learners on what to do next to support their progress or to correct their solution (Rivers, 2017). The next subsection will provide an overview of hints as a form of automated feedback.

Hints as a form of automated feedback

Hints are not a new notion in learning, it is a commonly used tactic by tutors (Hume, Michael, Rovick & Evens, 1996). Hume et al. (1996) define hinting as "the prompting of a student to recollect information presumed to be known to him or her, or the prompting of a student to make an inference needed to solve a problem or answer a question, or both" (p. 23). Generation of hints on ITS has a long history back to the late 80th - early 90th (Hume et al., 1996, Kim et al., 1989). In computer-based learning, hints are usually provided proactively when a learner makes errors or on-demand (requiring students to ask for a hint when they want or need one) (Razzaq, Heffernan, 2010). As Razzaq and Heffernan (2010) found, the learners that ask for higher

number of hints, hints-on-demand is a better choice while for “low-hinters” the type of hints did not make any difference. Wider perspectives on timing on feedback and hints provision will be given later in the section on the literature review.

Cummins et al. (2016) distinguish four motivations for using hints in learning: Decomposition, Correction, Verification and Comparison. Decomposition motivation comes when a learner is unable to start with solving a problem and needs help with decomposition into easier pieces (Cummins et al., 2016). According to the study that examined 4652 learners on a large-scale online learning environment, 66,35% of them use this strategy (Cummins et al., 2016). Correction strategy comes in when feedback needs to respond to “an incorrect answer being received” (Cummins et al., 2016, p. 108).

When a learner has answered but needs help with the incorrect answer - the Correction strategy comes in (Cummins et al., 2016). Out of 3984 learners that have submitted incorrect answers, 80,22% of them viewed hints afterwards (Cummins et al., 2016). Verification motivation comes before a learner submitted an answer and is willing to get a confirmation of whether it is correct or not (Cummins et al., 2016). The last type of hint usage motivation is Comparison. This comes after a learner gave a correct answer but willing to compare it to the teacher's solution (Cummins et al., 2016).

One way to provide hints is based on the next-step of learners (Rivers, 2017). Originally the next-step hints were given by marking each possible condition for students' solution or by making rules that could be matched with the students' work. Such an approach will work in domains where the number of possible states is small, but in a programming context, this approach is almost impossible since the environment for solving programming problems is unstructured and there are an infinite number of correct solutions to each problem (Rivers, 2017). An alternative to this traditional approach is to use a data-driven approach instead of trying to “hand-author hints” (Rivers, 2017, p. 2). The topic of data-driven hint generation is examined deeply from different perspectives (including the questions about the technical approach to next-step hints generation) in the research of Price, Dong and Lipovac (2017), Phothilimthana and Sridhara (2017) and Rivers (2017).

Types of automated feedback

Worked-examples

Several studies found that feedback through worked examples are commonly used in the learning process especially in the problem solving context (Rivers, 2017, Liu, Mostafavi, & Barnes, 2016, Shih, Koedinger & Scheines, 2011, Rahman & Boulay, 2010, Clarke, 2004). Liu, Mostafavi, & Barnes (2016) investigated worked examples and found that they benefit learners early on in the learning session, but hints can provide similar scaffolding. Worked examples are not as valuable later in the learning session and can even impact on reduction of performance level of low-proficiency learners (Liu, Mostafavi, & Barnes, 2016). The authors conclude by pointing that worked examples "may be complex and individual in environments for open-ended complex problem solving" (Liu, Mostafavi, & Barnes, 2016, p. 352). Rivers (2017) is pointing that future research should be done to answer the questions on how feedback through examples affect learning. How students perceive and use feedback through worked-examples.

Targeted feedback

Targeted feedback is another type of automated feedback distinguished in the literature (Qian & Lehman 2019, Hattie & Timperley, 2007, Ross, Jordan, & Butcher, 2006). Targeted feedback helps to reach to the correct solution even if learners' first attempt was wrong (Ross, Jordan, & Butcher, 2006). Qian and Lehman (2019) found that targeted feedback messages strengthen learners' improvements rates when solving programming problems. Particularly, the learners that were given targeted feedback in their study made "fewer intermediate incorrect solutions in their code than the once that were only receiving error messages from the original compiler" (Qian & Lehman, 2019, p. 15). The authors also added that targeted feedback can promote "conceptual change and facilitate learning" (Qian & Lehman, 2019, p. 15). Although studies point to the benefits of targeted feedback, there is a need in research about targeted feedback in order to understand how it benefits leaning and teaching (Qian & Lehman, 2019, Hattie & Timperley, 2007, Ross, Jordan, & Butcher, 2006).

Summary of the feedback in learning section

This section provided an overview of feedback in learning with special emphasis on views on what constitutes good feedback, types and forms of feedback. Research on automated feedback and hints has been a special focus in this section, as it contributes most to the objectives and research questions of this study. In the next section, factors that affect the use of automatic feedback and tips will be presenters.

Factors influencing use of automated feedback in learning

Although feedback is considered to facilitate learning, it is only effective and useful when it is timely and students can act on it (Carless et al., 2011). Carless et al. (2011) puts it crispy "the crux of the matter is how students interpret and use feedback" (Carless et al., 2011, p. 396). Similar to the help-seeking research presented earlier, research on feedback in learning distinguishes learner-related and feedback design specific factors that impact use of feedback (Rivers, 2017, Hattie & Timperley, 2007).

This section is going to present factors that impact use of automated feedback and hints when learning programming online.

Feedback design

Timing

The fact that timely feedback is one of the most crucial elements of the learning process has been supported by a number of research on feedback (Carless, et al., 2011; Shute, 2008; Blayney & Freeman, 2004). Questions about the effect of immediate versus delayed feedback on learning have been at the heart of discussions (Hattie & Timperley, 2007; Corbett & Anderson, 2001).

Immediate feedback is defined as that which is given exactly at the moment a student has responded to a problem or right when a problem was solved (Shute, 2008). Delayed feedback occurs some time (minutes, hours, days, etc.) after the task is completed or the problem is resolved (Shute, 2008). Shute (2008) mentioned the debate about the timing of feedback:

> *"Some researchers have argued for immediate feedback as a means to prevent errors being encoded into memory, whereas others have argued that delayed feedback reduces proactive interference, thus allowing the initial error to be forgotten and the correct information to be encoded with no interference" (Shute, 2008, p. 163).*

Corbett and Anderson (2001) focus on the question of when to give feedback in a programming context. Their findings show that immediate feedback is most beneficial for programming problem-solving tasks.

The question of timing of feedback in programming context is arised by Corbett and Anderson (2001). The authors found that immediate feedback is the most efficient for problem solving. Particularly, the learners that were given immediate feedback resolved the programming problems faster than the ones that had feedback on demand, error flagging and no-tutor conditions (Corbett & Anderson, 2001, p. 251). Based on the experiment Corbett and Anderson (2001) have performed the following conclusions on feedback design with relevance to timing were drawn:

> *"Immediate feedback on individual problem solving steps can be an efficient and effective form of tutorial support for students learning a complex problem solving skill such as programming." (Corbett & Anderson, 2001, p. 252).*

The authors also add that although more frequent immediate feedback is beneficial when students write a program, it is good to provide less immediate feedback to get students to focus on debugging the code they are writing (Corbett & Anderson, 2001).

Is it better to wait until a student requests help (on demand hints) or give a hint when a student makes a mistake (proactive hints)? Razzaq and Heffernan (2010) found that students who received on-demand hints were able to learn more than once who received proactive hints. This phenomenon was especially visible when students asked for a large number of tips. The same was observed by Rivers (2017) who found that having hints on-demand led to reduced time spent (by 13.7%) on performing practice problems while achieving the same learning outcomes as the students from the control group.

Aleven, et al. (2016) have performed an experiment. The authors found that hints-on demand "may support useful sense making, even if their effectiveness may vary by domain and by student, and even if, for any given student, hints may be effective only some of the time." "In addition, it seems clear also that Intelligent Tutoring systems (ITS) need bottom-out hints" ... "they help students get unstuck when they are stuck. In addition, bottom-out hints present useful opportunities for unprompted, spontaneous self-explanation. Self-explanation is associated with enhanced learning outcomes, even if not all students benefit equally" (Aleven, et al., 2016, p. 215). The authors also add that, on-demand " feedback can lead to improved "local domain-level learning" and a lasting increase in how deliberately students use help, although the hypothesis that this feedback would lead to improved out-of-tutor transfer of domain-level learning was not confirmed" (Aleven, et al., 2016, p. 218).

Feedback specificity

How much information to provide when giving feedback? Research shows the importance of providing specific, detailed, and clear feedback (Esterhazy & Damşa, 2017; Shute, 2008; Goodman, Wood & Hendrickx, 2004). At the same time, there are different dimensions to this notion. Goodman, et al. (2004) refer to feedback specificity as "the level of information presented in feedback messages" (p. 248). Specific (or elaborated) feedback is described by some authors as more directive than facilitative (Shute, 2008). Specific feedback has a higher

capacity to perform its information role than subjective feedback (Goodman, et al., 2004), and feedback that lacks specificity can be seen as useless, frustrating, and lead to uncertainty about how to act on the feedback. (Shute, 2008). The experiment performed by Goodman, et al. (2004) showed that increasing the specificity of the feedback intervention leads to higher initial performance. It was also found that “increasing feedback specificity led to less exploration of all kinds, greater use of systematic exploration during practice was positively related to learning, greater use of unsystematic exploration was detrimental to learning overall, and use of unsystematic exploration and hold steady strategies interacted with feedback specificity to affect learning” (Goodman, et al., 2004, p. 261).

Increasing the specificity of feedback thus has a beneficial effect in general; however, it is important to take into account learner characteristics (e.g. prior knowledge, skill level, motivation).

Rivers (2017) conducted an extended study to learn about students' experiences with hints where she found that more novice students needed much higher levels of content and detail in feedback comments than what was traditionally given. A similar phenomenon was found by Zhu, Liu and Lee (2020), but in contrast to River's study (2017), the authors found that this was applied for all students regardless level of experience with hints, they write that “contextualized feedback (context-dependent) was more effective in helping to learn than generic feedback (context-independent)”.

Aleven, Roll, McLaren & Koedinger (2016) elaborate on how hint messages should be designed to be effective. The authors write: “Hints should abstractly (but succinctly) characterize the problem-solving knowledge, by stating in general terms both the action to be taken, the conditions under which this particular action is appropriate, and the domain principle that justifies the action. Hints also need to explain briefly how the problem-solving principle applies to the given problem step” (Aleven, et al., 2016, p. 215).

Learner-related factors

Learning strategies

Similar to the research on help-seeking (Zarrin & Paixão, 2016), research in feedback highlights learning strategies or goal orientations as a factor influencing use of feedback. Researchers distinguish between two main strategies: "goal-oriented learning" and "performance-oriented learning" (Zhang & Hyland, 2018). Zhang and Hyland (2018) found that students with "goal-oriented learning" beliefs use both cognitive and affective strategies when engaging with feedback. In particular, these students seek to advance their skills and gain more knowledge as they learn. Students with "performance-oriented learning" strategies responde mechanically to feedback, lacking analytical and emotional aspects, according to Zhang and Hyland (2018). The same phenomenon was discovered in Nicol and Macfarlane‐Dick (2006) research, where the authors found that students with performance goals illustrated less motivation than those who focused on learning goals when they interacted with feedback.

Prior domain knowledge

Students' prior domain knowledge is another factor that facilitates productive feedback practices (Esterhazy & Damşa, 2017). Esterhazy & Damşa (2017) found that in order to make use of feedback not only do the students need to make sense of the feedback comments, but also to understand "underlying domain knowledge and strategies for working with that knowledge" (p. 271). Earlier study by Butler and Winne (1995) provide support for this argument by stating that feedback "is contextualized according to the student's correct knowledge and beliefs before cognitive tactics and strategies are used" (p. 264). Such views are also reflected in the work of Hattie and Timperley (2007), who found that feedback has all its power when it addresses misinterpretation, not a complete lack of understanding of the task context. In case the material is unknown or abstract to students, the feedback provision has very little effect on the creation performance since there is no way to link the new ideas to what is already known (Hattie & Timperley, 2007).

There are factors that are related to students' background knowledge and skills in certain areas that affect the level of engagement they have with feedback. Language proficiency is one of them. Zhang and Hyland (2018) found that students with higher levels of language knowledge may be better able to perceive feedback, leading to a deeper understanding of the content of feedback, and therefore, making feedback more useful. In contrast, when the language proficiency is low, “cognitive, behavioral and affective engagement” decreases, making it more difficult for students to make use of feedback (Zhang & Hyland, 2018, p. 99).

Summary of the literature review

This literature review presented findings from research on help-seeking behavior and feedback. All recent studies are common in the view that help-seeking behavior is an essential part of the learning process. Research shows that help-seeking impact on academic achievement and performance (Zarrin & Paixão, 2016; Williams & Takaku, 2011; Villavicencio, 2011; Karabenick, Newman, 2006; Ryan, Patrick & Serena, 2005; Karabenick, 2003). There are a number of factors that affect students' desire to seek help. The literature shows that there is correlation between help-seeking and the factors such as the achievement goal orientation, help-seeking threat, help-seeking attitudes, and student-related factors (Qayyum, 2018; Price, Dong & Lipovac, 2017; Zarrin & Paixão, 2016; Ryan, Patrick & Serena, 2005; Karabenick S., 2003). Some studies also mention relationships with teachers, learning strategies, help-seeking environment, academic efficacy, students' grade level as the factors that influence help-seeking (Qayyum A., 2018; Ryan, Patrick & Serena, 2005; Zarrin & Paixão, 2016; Newman & Schwager, 1995).

Research on types of help-seeking distinguishes different types of help-seeking behavior. Strategic, non-strategic and avoidant behavior were underlined by Karabenick (2003). Appropriate, avoidant, and dependent help-seeking behavior were distinguished by Ryan, Patrick and Serena (2005). Both of the categorizations refer to similar patterns in the help-seeking but the authors have based their categorizations on different factors. Karabenick (2003) used students' motivation, achievement goal orientation, learning strategies and performance as the

main indicators. While Ryan, Patrick and Serena (2005) based their categorization on help-seeking attitudes, achievement goal orientation, affective experiences, relationships with teachers, efficacy, fifth- and seventh-grade achievement. Literature on help-seeking online suggested that this approach to seek help is more engaging, and has a lot of benefits over the traditional help-seeking methods (Qayyum, 2018; Chyr et al., 2017). Research also shows that teachers prefer to use digital tools for providing help and students have a lower level of help-seeking threat when asking for help online (Qayyum, 2018; Hao et al., 2016).

Help in form of feedback is one one of the essential parts on learning and teaching (Meerah & Halim, 2011; Justin, Meredith & Rania, 2008; Hattie & Timperley, 2007; Blayney & Freeman, 2004; Askew & Lodge, 2004). Thus this literature review provides a comprehensive view on feedback in learning. One of the many definitions of feedback is given by Hattie and Timperley (2007). Feedback is "information provided by an agent (e.g. teacher, peer, book, parent, self, experience) regarding aspects of one's performance or understanding". There are two main feedback types extinguished in the literature: formative and summative. Formative feedback is the one that is provided on students' work and therefore, the focus of this review and the study overall was on formative feedback (Taylor & Silva, 2014; Shute, 2008). Not all formative feedback is considered as good and useful for learners. There are many good feedback practices presented in the literature. This review presented findings on what is considered as effective and sustainable feedback.

Literature shows that it is important to provide the correct form of feedback to facilitate learning for diverse populations (Taylor & Silva, 2014, Bower, 2005). Studies show that regular feedback in form of written or verbal feedback is not as interactive and effective as technology-supported feedback (Sheard, 2011; Carless et al., 2011; Chetwynd & Dobbyn, 2011; Race, 2005). The recent studies give special emphasis on automated feedback because it is more suitable for online and distance learning (Prather et al., 2018; Zhang & Hyland, 2018; Rivers, 2017; Carless et al., 2011; Ross, Jordan & Butcher, 2006). Automated feedback also shown to be more beneficial in programming context (Ott, 2015; Pears et al., 2007; Blayney & Freeman, 2004). Recent literature on computer science education has been discussing hints and generated next-step hints as a form of automated feedback (Price, Dong & Lipovac, 2017; Rivers, 2017). This literature review did not go deep into research on generated hints but work on the following authors is recommended:

Price, Dong and Lipovac (2017), Phothilimthana and Sridhara (2017) and Rivers (2017). Worked examples and targeted feedback are also in the focus on attention of research on automated feedback.

Although feedback wide research shows that feedback is facilitative for learning, it is only used by learners under certain conditions. The literature suggests that feedback design, content of feedback and learner-related factors are influencing automated feedback usage in the programming learning process (Zhang & Hyland, 2018; Esterhazy & Damşa, 2017; Carless, et al., 2011; Shute, 2008; Blayney & Freeman, 2004). Special emphasis is given to the topic of timing of feedback where the studies discuss immediate, delayed and feedback on-demand (Hattie & Timperley, 2007; Corbett & Anderson, 2001; Shute, 2008). Some research supports that immediate feedback is more efficient in learning a complex problem solving skill such as programming while delayed feedback is promoting knowledge retention and transfer of learning (Corbett & Anderson, 2001). Other studies (Rivers, 2017; Aleven, et al., 2016; Razzaq & Heffernan, 2010) support on-demand feedback arguing that this kind of hints can support sense making and improve local-domain level learning. Even though there is a lot of research done on the topic of feedback timing provision, the literature has no common option on when feedback should be provided to be useful for learning.

Range of studies indicated that there is a need for future research on help-seeking and automated feedback in order to support design and development of learning environments for learning programming online (Hao et al., 2016; Melanie, 2006; Mory, 2004). More research is needed to be done in forms on automated feedback, factors impacting the use of the feedback in learning with emphasis on problem-solving domains (Qian & Lehman, 2019; Rivers, 2017; Mory, 2004).

Chapter 3

Methodology

"The thing about technology and programming is that your education is never completed" (Participant E, Interview, August 2020).

This chapter presents the research design, methods to collect data, interviews and practice problem development, and method of analysis. Finally, the ethical issues and limitations are presented. The methodology used was focused on getting insights on participants' experience with help-seeking and automated feedback usage when learning programming online. The methods used in the study included qualitative interviews and observations.

The data collected from the interviews supported the understanding of the participants' perception of seeking help online. It also supported in gaining insight into the factors that affect the use of feedback based on the participants' previous experience. The data collected from the observations allowed to confirm and extend the data collected through the interviews. The data from the observations also supported in gaining insights about the participants' experience with automated feedback usage when solving programming problems.

Research design

To introduce the research design of this study, the research problem and the research questions should be reminded. The study is focused on the problem of insufficient knowledge in the topic help-seeking and automated feedback in learning to program online. The main research question that was investigated is: How do people use automated feedback when learning programming online? The secondary research questions were formulated as following:

1. How do people perceive help-seeking online?
2. What is the experience of using automatic feedback when solving programming problems reported by participants?
3. What factors impact on feedback usage when learning programming?

To solve the research problem, the objective was to understand phenomena of the use of help-seeking and automated feedback when learning to program online. This study includes two types of research questions: ‘how’ and ‘what’. The nature of the ‘how’ research questions is “concerned with bringing about change with some intervention” (Blaikie, 2010, p. 83).

The ‘what’ research questions facilitate in gaining knowledge “before we can be confident about intervening to change it” (Blaikie, 2010, p. 83). To answer the ‘what’ research questions, the inductive research strategy was chosen (Blaikie, 2010). The inductive strategy also supports achieving the study aim by establishing an understanding of help-seeking and automated feedback use (Blaikie, 2010).

Qualitative research design was proposed to achieve the study objectives with semi-structured interviews and observations being the research methods. The reason for choosing a qualitative approach is that qualitative studies are suitable for gaining a deeper understanding of underlying patterns, which is necessary to answer the main ‘how’ research question (Blaikie, 2010). Qualitative approaches are also commonly used in social science, in subjects such as education, development studies, to which this study contributes.

Population and Sampling Procedures

Population of interest

The target group of the study was young adults learning programming online. Purposive sampling method was used which is common in "situations where it is impossible or very costly to identify a particular population" (Blaikie, 2010, p. 178). The main purpose of sampling was to produce a sample that can be representative of a typical person learning programming online. Subjective methods were used to decide which criteria should be applied to be included in the sample. One of the criteria that was selected is previous programming knowledge. This criteria had adjusted after the pilot. The following additional criteria was added: having entry level knowledge in the programming language used for the task for the intervention (Python). Formal education was not the focus due to the fact that it does not represent a typical person learning programming online. Experience with programming was prioritized because it gives a wider insides on peoples’ help-seeking and use of automated feedback when learning to program online. It was decided to select a mix of people experienced with programming in professional

settings and people experienced from school. This choice was made to support the diverse population that is learning programming online or in distance learning.

The participants were recruited through personal and professional networks. The nonprofit organization Women in Technology Oslo has supported with resources by promoting the information about the study on their social media resources. The participants referred to the master student to be selected for the study based on the criteria described above.

The total number of 12 participants was selected to take part in the pilot and study. Two of them took part in the pilot and the data collected from the pilot was not analyzed. The 10 participants took part in the study.

Table 1. Background information the study participants sample

Ordinal letter	Professional experience with programming	Experience with Python
Participant A	1	0
Participant B	1	1
Participant C	1	1
Participant D	1	1
Participant E	1	1
Participant F	0	0
Participant G	0	0
Participant H	0	0
Participant I	0	0
Participant J	1	1

Digit 1 is associated with presents of the criteria. Digit 0 - corresponds to the absence of the criteria.

All of the participants had experience with programming. 60% of them had professionally worked with programming. 50% had prior experience with the Python programming language used for task intervention.

Study area & time

Oslo was chosen as the study area because it presents organizations that work with development countries by initiating programs with aim of providing programming education for youth and young adults. One of the organizations that the master student was collaborating with in the past was Plan International Norway. This organization implemented a program for young adults in Uganda to learn programming with a learning platform, Diggit, that facilitates online learning by providing help in the form of feedback. The Oslo area was selected as the study area also due to the fact that the access to the learning platform and opportunity to collaborate with the team that has developed and designed the learning platform was given. Lastly the fact that English was the main language of the study also has supported the decision of choosing Oslo as a study area.

Intervention

Practice problem objectives and development

The goal of the practice problem was to gain a better understanding of the participants' help-seeking behavior and the way they interact with the feedback provided during practice problems. The steps that facilitated reaching the goal were:

- Asking the participants to speak over their thinking process and comment all their actions while solving the practice problem;
- Recording the voice of the participants and recording the screen while they were solving the practice problem;
- Observing how the participants were solving the practice problem and taking notes;
- Providing hints when a participant asked for help or when they got stuck.

Procedural overview

The task for the intervention (it will be referred to as a practice problem) was developed in the following steps:

1. Research on practice problems for beginners was undertaken; Reviewing practice problems that master student had solutions for;

2. Testing a several practice problems by the means of the researcher; Reviewing time and complexity level of each practice problem; Choosing the most suitable practice problem for the study; Testing the selected practice problem with the three colleagues of the master student from Oslo Science Park;

3. Splitting the practice problem into stages; Creating list of potential hint messages for each part of the practice problem based on the seven principles of good feedback practice (Nicol & Macfarlane-Dick, 2006); Pilot test of the practice problem with the three colleagues of the master student from Oslo Science Park.

Choice of the programming language

Python programming language (Python) was chosen to be a programming language for the practice problem due to the fact that the master student can operate with Python freelly what gave a big advantage for the procedure of choosing the most suitable practice problem and making sense of the participants' logical process of solving practice problems.

Choosing the most suitable practice problem for the study

To choose the most suitable practice problem, a problem had to meet the following requirements:

- The practice problem had to be taken from a schoolbook or be a part of formal education curriculum. This gave the practice problem credibility and also confirmed that it was tested by the book or the curriculum authors; The practice problem had to be easy to understand without any domain background knowledge (knowledge of programming is

an exception). It had to be generic and non-specific domain knowledge such as biology, mathematics, economy, and others had to be required;

- The practice problem had to take 30-60 min to solve by a person with some basic knowledge of programming; A potential solution for the practice problem had to include 5-10 different programming concepts (e.g. if statement, variable, while loop, function, etc.).

Presentation of the practice problem

Write a Python function named get_continue that displays to the user "Do you want to continue (y/n): ", and continues to prompt the user until either uppercase or lowercase 'y' or 'n' is entered, returning (lowercase) 'y' or 'n' as the function value.

The expanded specifications and the potential solutions of the programming problem are presented in the Appendix B.

Pilot test of the practice problem

The practice problem was initially tested by three colleagues of the master student from Oslo Science Park. One of them had very limited knowledge of Python and two were experienced . The practice problem was shown to be understandable and solvable by the three people. The problem had multiple solutions that were not very diverse from each other. This made it more suitable for the study because it was easier to predict where the participants of the study could get stuck or/and ask for a hint.

After the first pilot group, the second pilot test was conducted with two study participants. One of the participants had an extensive programming experience but no previous experience with Python. The second participant had experience with Python and programming in general. After the test it was found that the practice problem was solvable for people with several years of experience in programming but if they do not know Python it was difficult to write a solution that would be executable. The reason for this is because each programming language has its own syntax. This problem could be solved by providing a cheat sheet with basic reference but that would overcomplicate the practice problem and will not facilitate the goal of the practice

problem. In the end of the second pilot test it was decided that participants of the study should have basic knowledge of Python.

Data collection and Analysis

Methods of data collection

Because the objective of the study is to gain insights in people's experience and perception, semi-structured interviews were utilised as one of the methods. The pre-interviews gave a wide picture of participants' reflection on help-seeking, using different types of help while learning to program, using feedback when solving programming problems, reflection on what is useful feedback and what is the best time to provide it. The choice to do pre-interviews was taken because of the complexity of the question of using help-seeking online and using help in the form of automated feedback. Pre-interviews with participants from various backgrounds provided a comprehensive understanding of the question from different angles. The interviews had a semi-structured character due to the fact that some of the questions were based on the previous answers of the participants. Semi-structured interviews provided in-depth understanding of the participants motivation, reasonings and emotions, therefore the choice to not follow a structured interview was made. Considering the scale, time and energy resource approach of taking pre-interviews had a clear advantage over some other methods such as statistical analysis or comparative study. The choice of the method can also be supported by the existing research on feedback (Rivers, 2017) and help-seeking online where one of the methods was interviews.

The research aim has a complex nature, having observations as a second method for the study, appears as a suitable option. As outlined by Cotton, Stokes and Cotton (2010), behaviour and "many situations where observational data—collected by a researcher or by students themselves using video, audio or written diaries—may provide a deeper insight into their experience" (p. 464). Screen recording and participants observations (will refer as observations) were conducted during this phase. Depending on the individual time that each participant used to solve the given practice problem, this part took from 20 minutes to 1 hour. The goal of the observations was to

understand how people seek help when solving programming problems, to hear their analytical process and to learn how they use help in the form of feedback. There was no intervention from the master student side to the participants' process of solving the practice problem, except if they asked for feedback through online chat.

Post interviews were conducted after the observations. The post interviews had a semi-structured approach and the questions were based and aimed to elaborate on the participants' help-seeking behavior, interaction with feedback and comments during the process of solving the programming problem. The presents of the post interviews gave a full presentation of the participants perception and experience with help-seeking and feedback usage online. The interview questions and the presentation of the practice problem are provided in the Appendix A and Appendix B.

The interviews and the observations were carried out in August - September 2020. The interviews and observations were recorded using an audio and a screen recording tool Loom and note-taking. The sessions took place physically in different locations in Oslo and online. Ideally all the data collection would have to be face-to-face in order to get a deeper understanding of the topic but due to COVID-19 regulations most of the physical activities had to be canceled. For the purpose of focusing better on each participant, each sample of interviews and observations was taken in its own time. Duration of each session was from one to two hours.

Data collection procedure

The procedure of data collection was carried out in August - September 2020. The following steps were taken to prepare for the data collection and for analysis:

1. The necessary permissions from Norwegian Centre for Research Data (Norsk senter for forskningsdata) were obtained.

2. An information letter that introduces the participants to the study overview, objectives and an overview of what participation in the study will include. The letter also included a section about the personal privacy and personal data, as well as the contacts of the

researcher, supervisor and the responsible university. The information letter can be provided in the Appendix C. A consent form for the study participants was created;

3. An interview instrument draft was designed; A list of expected answers was created; A modification to the interview instrument was made; A practice problem was created; Pilot test of the interviews and the practice problem was performed;

4. Announcement about inviting participants to join the study was created and published on social media; The participants were contacted via emails and the information letter with a consent form was distributed.

Interview instrument development

To develop a relevant pre interview and post interview instrument for the research, were taken the following steps:

1. Reading literature on the topic (Hao et al., 2016; Melanie, 2006; Mory, 2004) and underlining the questions that needed more attention; Researching on existing interview instruments;

2. Developing a pre and a post interview instruments:

   Creating a list of expected answers; Modifying the pre and post interview instruments; Matching the pre interview instrument to the post interview instrument; Matching the post interview to the potential observations from the practice problem;

3. Pilot testing of the pre interview instrument, practice problem and post interview instrument; Adjusting the pre and post interview based on the pilot test findings.

Method of analysis

The interviews and observations were transcribed and thematic analysis was carried out. This involved labeling (coding) all the data, identifying patterns and creating key themes.

Table 1. Turning codes into themes

Codes	Themes
● Help-seeking source ● Useful help ● Help-seeking online	Help-seeking
● Useful ● Helpful ● Good ● Motivating ● Encouraging	What is a good feedback?
Factors impacting use of automated feedback	
● Timing ● Details & specificity ● Frequency	Feedback design
● Learning goals ● Prior experience with programming ● Prior experience with feedback	Learners-related factors
● Test scripts ● Debugging methods	Content of feedback
● Feedback through example ● Best practice ● Code snippets ● Next-step hints (pointing to how to improve learner's solution)	Feedback types

First I analysed the data collected from the pre-interviews, so it was possible to draw potential correlations when analyzing the data collected from observations. Lastly the data collected from post interviews was analyzed. Thematic analysis was used to analyze the data because it is an essential tool for identifying and interpreting patterns, characteristics and themes in qualitative data (Braun & Clarke, 2006). A combination of inductive and deductive orientations was taken for the analisis. The key themes development determined by the content of data and existing concepts presented in the literature review (Dubois & Gadde, 2014; Braun & Clarke, 2006).

The following steps were undertaken to do reflexive analysis. First, the familiarisation with data took place. This included transcribing the data collected from interviews and observations. Verbatim transcription was used to transcribe the data, in other words, every single word was written down. The transcriptions were also altered. The transcribed data was then read through and encoded. Succinct labels were generated to identify main patterns in the dataset that might be relevant for reaching the research objective. Initial themes were generated based on the key patterns found in the data and the patterns found in the existing theory (Dubois & Gadde, 2014).

Ethical Issues

The main ethical issues could arise in the possibility of the data from the interviews being not relevant to the study. Since the interviews were semi-structured there is a chance that some of the participants' answers took longer time but did not provide relevant information for the study objectives. Due to the fact that some of the questions were sensitive in the way they could raise some knowledge gaps, it could be assumed that some participants were not entirely frank. A similar issue could be present in the practice problem part, where some of the participants could be embarrassed to use any kind of help because of potential pressure created from the interviewer. To avoid such ethical challenges in the practice problem part, a natural environment for solving programming problems was created. Particularly, participants were given a separate computer to solve the task or they were using their own computer. Also, a friendly and accepting atmosphere was created.

Chapter 4

Findings and Discussion

"If the hints are available too soon then I also feel like I am not learning. I had experience with courses like that and I do not remember a thing. I feel like learning is associated with some spended energy and some pain" (Participant E, Interview, August 2020).

Findings

This section reports the results of data analysis of from 10 data samples[2]. The data was collected using the following qualitative methods: pre-interview, observations, post-interviews. All of the participants had experience with programming. 60% of them had professionally worked with programming. 50% had prior experience with the Python programming language used for task intervention. The data was analyzed using thematic analysis as it is an essential tool for identifying patterns across qualitative dataset (Braun & Clarke, 2006).

The results are structured based on the key themes that emerged from the analysis of the data and the literature review. First, the results about help-seeking are presented, followed by the results on what is good feedback. Then the results related to the factors impacting use of automated feedback are presented. The results regarding the factors are presented as follows: feedback design, learners-related factors, content feedback and feedback types. The results are presented in the order of how frequent they were mentioned in the participants responses.

Help-seeking

Help-seeking sources

When asked participants how they seek help. Some mentioned books (Participant E, I, A, Interview), colleagues help (Participant H, Interview), documentation (Participant J, Interview), peers (Participant J, F, Interview). Some also mentioned getting help from their teachers and teaching assistance (Participant A, I, Interview). One of the participants explained her help-seeking process as follows:

"In the Java course I got this thick book and then we also had a lot of supplementary websites. The book was just about - if you do this, it will output that. My strategy was: go to the lecture, listen to the teacher and try to understand what they are saying. The teachers would tell you: Ask

[2] There were a total of 12 participants, but two of them were in the pilot, and the data collected in the pilot was not sufficient for the data analyzes.

any question, no question is dumb. But then after the whole lecture I had no clue what he was saying and I had a bunch of questions and I don't even know what my question was. And I felt like I could not say - I do not understand everything, can you repeat please? So the lectures did not work. The teacher assistance did not work either. At the end, I used Youtube - when there was a topic, I would ask the teacher assistant, I would ask a teacher, I would read about that and they would not help me. It was not clicking. So I would go with Youtube videos and they would take it step by step and use different examples and that would help." (Participant A, Interview)

Help-seeking online

When asked specifically about getting help from online resources. All the participants mentioned Google as a source of seeking help online. Some referred to online forums (Participant J, Interview), online tutorials (Participant I, F, C, Interview). Youtube as a source of help was mentioned by Participant H, E, F, C.

StackOverflow was the next source for help (Participant J, B). Participant J reflected that when he "*just started learning programming - StackOverflow was not very helpful because it was not always easy to formulate the question or the problem I was experiencing" (Interview)*.

All the participants mentioned that they had some experience with seeking help on online learning platforms for the purpose of learning programming or/and learning data science. Participants E and H mentioned that they do not prefer to seek help through online tools (Interview). Participant J said that about his experience with one online learning platform: "it was very helpful because they were giving me feedback".

Reflection on help-seeking and feedback

When asked about reflection on help-seeking and feedabck participants used the following adjectives associated with their experience: *"pointless", "easier", "helpful", "useful", "stupid", "good", "hard", "not clicking" "painful", "engaging", "motivating", "inviting "*. The

following verbs were associated with help-seeking and feedback use: *"struggled", "liked", "does not work", "do not get it"*.

Feedback in learning

Experience with feedback

Half of the participants explicitly said that getting help in the form of feedback was helpful during the learning process:

"I did get feedback on Udacity's learning platform. It was useful because they explained to me how to improve my solution" (Participant J, Interview).

"The user interface on DataCamp was good because you can troubleshoot your solution and see if there is an error. It helps a lot" (Participant B, Interview). Another participant supported the frustration: *"There were no hints on how to improve my solution or similar so it was a bit problematic" (Participant J, Interview).*

Reflection on what is good feedback?

When asked what is good feedback, one of the experienced participants said that "Explanation is good" but it should provide "*the level of the details that you need, clear message*" (Participant B, Interview).

Low-quality feedback (characteristic): Some of the participants elaborated on what they considered a low-quality feedback. Feedback in the form of an example of how a programming problem could be solved that is very different from the solution a student is submitting was considered as poor quality feedback (Participant J, F, Interview). Feedback that is binary (passed or not passed) was also mentioned in the category of low-quality feedback (Participant C, J, Interview). Feedback that points to presents of an error in your solution: Participant H mentioned that having an indicator that points to presents of an error in her solution was "*useful to some extent but since it just shows you where the error you still have to resolve the error on your own*" (Interview).

Feedback design

Timing

Timing of the feedback as an indicator for using feedback was mentioned by all the study participants.

Delayed feedback: Participant A, R, C, E, D, J said that if they are solving a programming problem with an aim of learning - they would rather prefer delayed feedback so they have time to think and come up with a solution themselves (Interview). Participant E put it into words: "*I think this is a super difficult question to answer because I do not like to be frustrated and do it for too long. But if the hints are available too soon then I also feel like I am not learning. I had experience with courses like that and I do not remember anything. I feel like learning is associated with some spended energy and some pain. Like if you are not frustrated and if it is not a bit painful then you probably knew it before or you haven't done anything, like you did not understand. So from that perspective I feel like there is some slot of the time before people should be allowed to get feedback. Like I do not know that if I am stuck - I can be given help but I also do not want to help you immediately because I want you to think about that right now. And if I did not understand - maybe there is something in the question or maybe there is something I'm getting backwards so then it would be good to have some help. So after I tried. I think that would be my preference" (Interview)*.

Immediate feedback: Participant F, G, H, I said that they prefer immediate feedback because it reduces time spent on solving a problem and reduces frustration (Interview & Observation). The notes from one of the observations mentioned that she was commenting on the desire to have feedback as she got stuck (Participant G, Observation).

Feedback on-demand: Participant J mentioned that he would like to get on-demand feedback depending on some criterias: "*That depends on the task because usually I would choose this to be my choice - to get a hint or not to get" (Interview)*.

Validation feedback: Participant H and C mentioned that they would like to get feedback even when they have already submitted their solution (Interview). They would like to see other ways

of solving the problem. "*This editor that I used - you can validate the code and when you click on the validate button. They have this indicator that will be red if you have an error. So that was a useful function, it is easier than looking on your own*" (Interview).

Feedback types

Feedback through examples: All the participants mentioned feedback through examples in their interviews and half of them have explicitly said that they consider it to be useful: "*If you are presented with a few examples of how to solve the problem - it might be a good strategy for actual learning. It is more stimulating, you need to be more reflective and mindful*." (Participant H, Interview).

Next-step hint: One of the participants said: "I think I would want the next step or a way to think about that problem." (Participant E, Interview).

Details & specificity

When asked how detailed the feedback message should be, 4/10 participants said that feedback regarding "*abstract concepts*" and regarding higher levels of the program implementation would be useful (Participant B, D, E, J, Interview & Observation).

Participant B and E referred to the fact that it can be challenging to get the right feedback for them because they need to get feedback that is right for their level of experience (Interview). So the feedback should be not too detailed and be exactly to the point. "Explanation is good but sometimes you get feedback from someone that does not know you well so maybe explanation will be more detailed than what you need. But if you have sufficient information that you need this is the best feedback. So the level of the details that you need, clear message" (Participant B , Interview).

Learners-related factors

Learning goals: Participants E and B said that if they are solving a programming problem with an aim of learning - they would rather prefer delayed feedback so they have time to think and come up with a solution themselves (Interview & Observation). "*For learning, if you have this task at the end of a day, it would be better to do it on my own*" (Participant B, Observation). "*I feel like learning is associated with some spended energy and some pain.*" so he concluded that he would like to get feedback "*after I tried*" (Participant E, Interview).

Content of feedback

Syntax error: From the observations it was found that the Participants B, C, F, G, H, I asked frequently for feedback regarding syntax of the programming language (Observations). One participant that had challenges with solving the practice problem said that "*If i need any help it is regarding syntax" (Participant F, Observation*). Feedback on syntax errors was also mentioned by Participant A that had extended experience in programming but had no prior knowledge of Python (Observations).

At the same time some it was mentioned that feedback that simply points that "t*here is a syntax error*" is not as useful as "*if your answer can be analysed - and feedback would be based on your answer*" (Participant B, Interview & Observation).

Step-by-step hints: Participants mentioned that they wanted to have feedback on how to solve the programming problem step by step (Participant A, F, H, Observation & Interview). One of the experienced participants said: " *I would be interested in getting hints based on where I am failing or if I just say - I can not resolve this question and it does not give you the answer but it says - try this, hints you step by step until you get into the answer*" (Participant A, Interview). Participant H said that she used to "r*eceive instructions step by step*" and therefore, she concluded, "*step by step feedback message*" would be helpful (Interview & Observation). Participant F added that if she was given hints after each step of submission it will be helpful. (Observation).

Cheetshit in the feedback: Participant A solved the practice problem but was not able to run it (compile) at all because of the syntax errors (Observation). She referred to cheetshit with code examples to be useful (Participant A, Observation). Participant H said: *"if I had my notes (cheatsheet) it would be helpful" (Interview)*.

Feedback that helps to improve learners' solutions was mentioned by all the participants in the positive context. Participants J, I, C and E said that it would be great to have feedback on how to improve their solution, to make it faster, make it cleaner (Interviews).

Participants B and J pointed that the content of feedback would depend on what kind of programming problem he is solving - if it is something complex he would like to get feedback on design of the solution, program, algorithm (Interview). If it is a simple program they do not need feedback on design of the solution (Participant B, Interview).

Hint as a test: Participant E, H and G mentioned that having test scripts in a feedback message would be useful (Interview). Participant E explained what he ment under hint as a test: It can provide the message "*try to test it, like try to run it with those different imports"* (Interview). Exactly the same was observed from Participant B practice problem. "*Potentially, to save his time a feedback message could be: Try to use a few input values and see what print outputs*" (Observation).

Hint that points to design specifications is also mentioned by the same participants, the hint could tell: *"you are covering this design specifications, this design specifications but not this and that, and, maybe the test would not pass*" (Participant E, Interview).

None of the participants have explicitly mentioned about having debugging methods in feedback messages. But the analysis of the notes taken from the observations show that most of the participants referred to debugging methods when running into an error (Observation). One of the participants reflected on his action while resolving the practice problem: *"I'm going to print the key every time. So it's kind of a debugger to see if it is giving a real value or not*" (Participant B, Observation).

Participants A, B, C, D, E, J mentioned using debugging methods as their problem solving strategy: *"I also try to take a problem and divide it into smaller problems and try to solve it part by part*" (Participant J, Interview).

Discussion

This chapter will discuss the key findings of this study and are presented in the previous chapter. In order to discuss the study's findings, the research objective should be reminded. The research aim was to explore how people seek help and automated feedback usage in learning to program online. It should be noted that the findings of this study have addressed the 'what' research questions in a brighter picture than the 'how' questions. Therefore the discussion will focus on the research questions related to participants' experience using automated feedback in solving programming problems and what factors impact on the use of automated feedback.

The central finding of this study is that timing is one of the essential factors that impact feedback usage when solving programming problems online. The findings also show that timing of feedback provisioning has correlation with several factors that impact learners' desire to seek help in form of feedback and to make use of this feedback. It was also supported by the research that timely feedback is one of the crucial elements impacting feedback usage (Carless, et al., 2011; Bruno & Santos, 2010; Shute, 2008; Blayney & Freeman, 2004).

Delayed feedback and learners prior programming experience

The findings show that having prior experience with programming correlated with the preferred timing of feedback provision. The participants with professional background in programming referred to having delayed feedback as useful. There were several reasons that the participants referred to, particularly they mentioned that delayed feedback is supporting autonomy, knowledge retention.

Delayed feedback for self-regulated learning

The findings show that participants were aware of delayed feedback facilitating analytical, more deep and mindful learning. They thought that struggle and frustration is a part of the learning process and "if it is not a bit painful then you probably haven't done anything". It can be

concluded that delayed feedback is associated with self-regulated learning as it encourages learners to try to find solutions themselves. The same was found in the previous research. Shute (2008) stated that "delayed feedback may encourage learners' engagement in active cognitive and metacognitive processing, thus engendering a sense of autonomy (and perhaps improved self-efficacy)" (p. 165).

Delayed feedback for knowledge retention

The study also shows that delayed feedback is facilitative for learning in the long run, because it helps to remember material from the course, lesson, assignment. As one of the participants said: "If the hints are available too soon then I feel like I am not learning. I had experience with courses like that and I do not remember anything".

The same was found in the literature that compared delayed to immediate feedback. As Shute (2008) referred to Schroth (1992) and Corbett and Anderson (2001) findings "delayed feedback may be superior for promoting transfer of learning, especially in relation to concept-formation tasks" (p. 165). "The superiority of delayed feedback, referred to as the delay-retention effect (DRE), was supported in a series of experiments by Anderson and colleagues (e.g., Kulhavy & Anderson, 1972; Surber & Anderson, 1975), comparing the accuracy of responses on a retention test with the accuracy of responses on an initial test" (Shute, 2008, p. 163).

Need for immediate feedback

The study shows that need for immediate feedback was associated with presents of a deadline, unwillingness to be frustrated and need for help to start with a task. Three of the participants associated preference of immediate feedback with a deadline or limited time on an assignment (Participant B, E, C, Interview & Observation). To support this, one of the Participant B reflected after the practice problem: "Because we are running out of time it was really good to have the hint when I got stuck even though I'm a person who likes to find a solution myself" (Interview).

This study also showed that preference for immediate feedback was associated with reluctance to be frustrated, feel stuck and spend too much time on a task. This reflection was associated with

participants that had no prior professional experience with programming. It can be assumed that the learning goals of these participants is to perform tasks correctly, thus the immediate feedback is playing a facilitative role in reaching their goal (Observation). The fact that immediate feedback is supporting learning in the short run was also mentioned in the prior literature (Shute, 2008).

This study also found that having immediate feedback was associated with a need to kick start or with desire to progress. In particular, participants who struggle the most with the practice problem and with the syntax of the programming language asked for a hint to start solving the practice problem. The immediate feedback in this context was playing a facilitative role and was bootstrapping participants progress. A similar finding was mentioned in the literature. Shute (2008) mentioned that immediate feedback facilitates motivation to practice, progress and provides "the explicit association of outcomes to causes" (p. 165).

This study showed that need for immediate feedback is associated with presents of deadline or lack of time. The conclusion can be drawn based on the study findings and the previous research (Shute, 2008): when one has a deadline and has to deliver an assignment in a short time the goal of solving a programming problem would not be associated with learning but completion. Those referring to the previous discussion on how the goal of learning and knowledge retention are associated with openless for delayed feedback and the frustration associated with it - it can be concluded that: learning strategy is correlated with timing of feedback. Similar conclusion was outlined by Shute (2008) "delaying feedback for struggling and less motivated learners may prove to be frustrating and detrimental to their knowledge and skill acquisition" (p. 165).

Motivations to use hints in learning

This study findings have confirmed broader research on motivation for using hints when learning programming. The study participants expressed all the four motivations strategies described by Cummins et al. (2016). Particularly, Decomposition motivation was expressed by three of the study participants that have explicitly mentioned that they would like to receive a hint to get started. "If you get stuck for any reason you need to have this kick start hint in order to progress" - an experienced study participant mentioned. In the literature decomposition motivation

approach implies a desire of learners to get feedback when they are unable to start on a task Cummins et al. (2016). In the study by Cummins et al. (2016), 66,35%[3] of the study participants referred to this motivation behavior. In this study 30% participants referred to decomposition.

Limitations of this study

There are several limitations in this study. First of all is the technical limitation. Because the practice problem should include performance of a programming task the necessary software had to be set up. Because of the time and technical complexity, the practice problem includes some manual steps that facilitated the data collection. That said, there were ways to make the performance of the practice problem more automatic but that would require more time to be putten into the development of the technical base for the practice problem.

The second limitation is in timing. Due to the limited time frame, the research design had to be adjusted to make sure that the deadlines are met. Since in-depth interviews were chosen to be a part of the methodology, it took some extra time to conduct and to analyse the data from the interviews.

The third limitation is the access to the right target group. As it was mentioned in the previous chapters, the basic requirement for taking part in the study is the introductory knowledge of Python. That said, it was also important to have a balance between experience with programming and novice people. Lastly, the number of participants was a big limitation. Due to the time and energy concerns the number of participants had to be limited which could lead to some statistically insignificant results. At the same time, due to the small number of participants, a more personalized approach to the interviews and the practice problem was taken.

Another significant limitation that is very common to most of the studies made in the time of COVID-19 is that some of the meetings in person were moved to the digital space. The fact that some of the regulations regarding how many people can gather in one place during COVID-19 pandemic were changing a lot over the month the study was done, made it challenging to plan

[3] The study examined 4652 learners on a large-scale online learning environment (Cummins et al., 2016).

ahead on how the research design should look like. That made a big pivot in how the study was done at the end.

Future research and recommendations

Future research to explore how people seek help and use automated feedback when learning to program online is necessary. Particularly this study has shown that the timing if the feedback provision needs to be studied more because it plays a crucial role when it comes to learners' desire to seek for help or use feedback.

This study supported the previous literature in the way that it is difficult to conclude when they want the feedback to be presented because on one hand they do not want to struggle for too long and be frustrated and discouraged but on the other hand they do not want to get a hint immediately. The same was found by Shute (2008), who reported that "there are conflicting results in the literature relating to the timing of feedback and the effects on learning outcome and efficiency" (p. 163). Future research is needed to understand better when hints should be provided to facilitate learning of programming. A closer look at how prior experience is correlated with feedback timing is also a question for research. In order to provide a more coherent argument regarding how delayed feedback correlates with knowledge retention a longer and higher scale study is necessary.

Despite a small scale of this study, the findings suggest that there is a room for improvements in design and development of the learning environment to facilitate diverse populations to study online. The central finding of the study suggests that close attention to the *timing of feedback provision* on learning platforms has to be given. The factors such as prior learner experience, learning goals and presents of time restriction impact on when feedback should be provided and whether it will be used by learners.

Conclusion

Education in remote areas has been in the focus of the recent policies, news and research. This topic is especially relevant in the times of epidemic that we live in now. The opportunity to provide accessible and open education for diverse populations is one of the focuses of the UN's Sustainable Development Goals.

Programming education has proven to be specially relevant to support development in remote areas. While programming is considered to be a new literacy, it also can affect the employment rate, gender issues, and therefore increase the livelihoods of local communities and individuals. Learning programming through online tools is one of the common teaching and learning methods. While learning is supported by various factors, feedback is considered to be the main facilitator of learning (Mackinnon et al., 2016; Hounsell, 2007). In order to support the diverse population this study has addressed the questions on how people seek help online, use feedback when learning to program online, what is their experience and what factors impact feedback usage.

The qualitative research design was undertaken to address these questions. Interviews and observations were performed on a sample of 12 participants. The study took place in Oslo, Norway. Because of the nature of the study questions that are focused on exploring the patterns in learners behavior, the main methods for the data collection used were thematic analysis.

The central finding of the study suggests that close attention to the *timing of feedback provision* on learning platforms has to be given. It is important to take into account the prior experience of learners when deciding on when feedback should be given: immediate, on-demand or deployed. The factor related to the learning goals is also necessary to take into account. It was found that people with lifelong learning goals have preference for delayed feedback as it facilitated their analytical processes. The learners with short term learning goals have a preference for immediate feedback. The study also showed that validation feedback is commonly used by learners to confirm their solution before summation. Thus the various factors impact on when the automated feedback should be provided when learning programming online.

In conclusion, this study suggests to continue research that can facilitate remote learning to program as it contributes to the development of local communities and individuals. The trend of learning online and distance learning is going to incrementally grow and to make sure that the education is equipped with the right tools for supporting this type of learning is important.

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Appendix

Appendix A – Interview questions instrument

Pre interview questions

Part 1. General questions about prior knowledge & help-seeking

1) How many years of experience in programming do you have? (Include official work experience or work on personal projects)
2) What is the number of years of education in programming you have? (self-education also counts)
3) What programming languages have you used before?
4) How did you learn programming?
5) Can you briefly tell about your experience learning to program? What were things that helped you in the process? What were things that you found not helpful? (e.g. communities, teaching method, learning platform, complexity level of the programming language, etc.)
6) What help have you used for learning to program?
7) What was your experience with using online learning platforms for getting help?

Part 2. Help-seeking in programming context & experience with feedback

8) What kind of help do you use the most when solving programming problems (for school or at work)?
9) Can you briefly describe a typical process of solving a programming problem? What kind of help do you prefer to refer to?

10) Did you have any experience with getting help in the form of feedback / hints while solving a programming problem? Did you use the feedback / hints? Why did you use them or why did you skip it?

11) If you had used feedback when solving a programming problem, where did it come in place?

12) What is a useful feedback/hint for you? What feedback/hint you find not helpful?

13) When do you think feedback / hints should be given to support you in solving a programming problem?

Post interview questions

Part 1. Experience with solving programming problem and use of hints

1) Was the programming problem easy or was it difficult? What made it easy / difficult for you?

2) Did you use the feedback / hints when you solved the programming problem? Why did you use them or why did you skip it?

3) Where did the use of feedback / hints come into play?

4) Did you get any feedback / hints you consider useful? What made it useful? Did you get any feedback / hints you consider useless? What made it useless?

5) If you used feedback / hints when solving a programming problem, did it help you solve the problem? What do you think was useful in the feedback / hints? What do you think was not helpful?

6) When do you think feedback / hints should be given to support you in solving the programming problem?

Appendix B – Practice problem

Write a Python function named get_continue that displays to the user “Do you want to continue (y/n): ”, and continues to prompt the user until either uppercase or lowercase 'y' or 'n' is entered, returning (lowercase) 'y' or 'n' as the function value.

Specifications and the potential solutions of the task are provided in the Appendix B.

Specifications of the task or key elements checklist:

- Function should be named `get_continue`;
- Check that the input is `y` or `n`;
- Check that it returns `y` or `n`;
- The function should not need parameters, and be callable as `get_continue()`;
- If valid input is not given, then the function should be repeating the question until the input is valid.

In the following table the three potential solutions for the practice problem are provided.

Table 2. Potential solutions for the practice problem

```
# SOLUTION 1

def get_continue():
    choice = input('Do you want to continue (y/n):   ')
    if choice.lower() in ['y','n']:
        return choice.lower()
    else:
        print('Please enter a valid choice')
        return get_continue()

get_continue()
```

```
# SOLUTION 2

def get_continue():
    choice =  input('Do you want to continue (y/n):   ')
    looping = True
    while looping:
        if choice in ('y','Y','N','n'):
            if choice  == 'y':
                return 'y'
```

```
            elif choice == 'Y':
                return 'y'
            elif choice == 'n':
                return 'n'
            elif choice == 'N':
                return 'n'
        else:
            print('Please enter a valid choice')
            choice = input('Do you want to continue (y/n):  ')

get_continue()
```

```
# SOLUTION 3

def get_continue():
    choice = ' '
    while choice.lower() not in ['y','n']:
        choice = input('Do you want to continue (y/n):   ')
    return choice

get_continue()
```

Appendix C – Information Letter

This is an inquiry about participation in the research project "The role of automated feedback in learning to program - Puzzle pieces of ICT-supported education for sustainability". In this letter we will give you information about the purpose of the project and what your participation will involve.

Purpose of the project

In my study I examine how people seek help online and feedback can be used to support students who may not have access to regular education. I do this by investigating how people seek help and use automatic feedback when solving programming problems. The project is a master's thesis and the collected data will only be used for the purposes of the thesis by the master student in the timeframe of 22.06.2020 — 31.12.2020.

Responsible for the research project

University of Agder, Department of global development and planning is the institution responsible for the project.

Why are you being asked to participate?

You are asked to participate in the research because your profile meets the criteria to be a participant in the study. The main criteria are to have an entry-level knowledge in Python programming language (Python).

What does participation involve?

If you will like to take part in the study, it will include your involvement in:

1. Pre-interview (20 min)
2. Practice problem (30 - 60 min)
3. Post-interview (20 min)

Expected time spent: The whole activity will be about 1 - 2 hours long, and it is done at the time that suits you.

More details on interview and the practice problem

The pre-interview includes questions on the following topics: General programming experience; Help-seeking behavior online and experience with feedback.

In the practice problem part, you will solve one entry-level programming problem using Python. The master student will observe your actions and note your thinking process while you solve the practice problem. There the screen of the laptop where you solve the problem will be recorded. The next section provides information on how data privacy will be handled during the screen capturing process.

The post-interview will include the questions on the following topics: Experience with the practice problem; Experience with the feedback.

Your personal privacy

During the practice problem part, we will collect information using the Loom application. The screen video is stored on the master student's Loom web profile and will only be available to the master student. The video will only be used for the purpose of the project, and it will be deleted when the project is completed. Read more about how the Loom application handles security and privacy here: https://support.loom/Security-Privacy.

Participation is voluntary

Participation in the project is voluntary. If you choose to participate, you can withdraw your consent at any time without giving a reason by sending an email to marina.webdev@com. All information about you will then be deleted. There will be no negative consequences for you if you choose not to participate or later decide to withdraw.

Your personal privacy – how we will store and use your personal data

We will only use your personal data for the purpose(s) specified in this information letter. We will process your personal data confidentially and in accordance with data protection legislation (the General Data Protection Regulation in Norway and Europe.).

Only the master student is going to have access to the personal data. To ensure that no unauthorized persons have access to the name and email this data will be replaced with a code. The list of respective codes will be stored separately from the rest of the collected data. None of the participants is going to be recognized in the publication (no reference to name or other traceable information).

What will happen to your personal data at the end of the research project?

The project is scheduled for December 15th 2020. The collected data is going to be deleted from digital devices and from the cloud. None of the personal data is going to be further stored/used.

Your rights

So long as you can be identified in the collected data, you have the right to:

- access the personal data that is being processed about you
- request that your personal data is deleted
- request that incorrect personal data about you is corrected/rectified
- receive a copy of your personal data (data portability), and
- send a complaint to the Data Protection Officer or The Norwegian Data Protection Authority regarding the processing of your personal data

What gives us the right to process your personal data?

We will process your personal data based on your consent. Based on an agreement with University of Agder, Department of global development and planning, NSD – The Norwegian Centre for Research Data AS has assessed that the processing of personal data in this project is in accordance with data protection legislation.

Where can I find out more?

If you have questions about the project, or want to exercise your rights, contact:

University of Agder, Department of global development and planning

Marina Gotovkina, researcher. Email: marina.webdev@gmail.com

Vito Laterzathe, Associate Professor and responsible for the master's thesis. Email: vito.laterza@uia.no

Data Protection Officer: Universitetet i Agder Privacy protection ombud. Email: personvernombud@uia.no

NSD – The Norwegian Centre for Research Data AS. Email: personverntjenester@nsd.no or phone: +47 55 58 21 17.