Sanna Oinas

Technology-enhanced feedback

teachers' practices, pupils' perceptions
and their relations to learning and academic well-being

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Abstract

Technology-enhanced feedback has been studied mostly in terms of task performance, but there is a limited amount of evidence about technology-enhanced feedback related to learning and behaviour during school lessons. However, this type of technology-enhanced feedback delivered using predefined options has been used on a daily basis in education for the last twenty years. As feedback may have beneficial but also detrimental effects on cognitive and emotional processing, this study was conducted to evaluate the relations of technology-enhanced feedback with the learning and academic well-being of pupils. Teachers' practices and pupils' perceptions were studied by analysing three data sets with mixed methods. The four sub-studies of this thesis were conducted in a Finnish context, where technology-enhanced feedback is utilised using a single online platform. However, the results of this dissertation are also internationally valuable, as there are dozens of both commercial and non-profit educational platforms throughout the world enabling technology-enhanced feedback, which may have a powerful effect on our children and adolescence.

The first data of this dissertation were analysed and reported in sub-studies I and II. This consisted of 211,003 authentic technology-enhanced feedback notes drawn directly from the online platform. Results revealed that, based on profile analysis, teachers deliver feedback using different patterns for their pupils (N=7,811) even in a single teaching group. Small groups of boys and pupils needing extra support for their studies were likely to receive more negative feedback compared to other groups. However, the great majority of all technology-enhanced feedback was positive in content.

The second data of pupils' (N=2,031) self-reported technology-enhanced feedback used in the sub-study III confirmed the findings from the first data. Furthermore, the relations between received technology-enhanced feedback and indicators measuring learning and academic well-being were studied. According to the results, the more positive feedback pupils received, the higher they rated their motivation, competence and relationship with teachers. Interestingly, those pupils

who reported that they never receive technology-enhanced feedback perceived their indicators measuring learning and academic well-being as the weakest.

The third data consisting of interviews (N=64) and a short questionnaire (N=132) were analysed in sub-study IV. Data collected and analysed with qualitative methods showed that pupils were mainly contented with technology-enhanced feedback. They reported that they need remarks from teacher in order to regulate their behaviour, as they considered it important at school. Moreover, pupils reported experiencing a variety of both pleasant and unpleasant emotions in relation to technology-enhanced feedback.

Based on the evidence of this study, it was concluded that technology-enhanced feedback, delivered mainly related to behaviour, is related to pupils' learning and academic well-being. For some pupils, such feedback can be motivating, but for others it can be frustrating or even represent a silent sign of being ignored. Therefore, guidelines should be formed in order to support pupils' learning and academic well-being equally in terms of technology-enhanced feedback.

Finally, based on the results of this study, a model of a technology-enhanced feedback process building up from self-regulated learning and feedback as a process is proposed. The model suggests that by regulating cognitive and affective processes consciously, pupils can actively seek and take advantage of technology-enhanced feedback themselves. First, however, they need to be supported to develop their self-regulation in collaboration with the teacher.

Sanna Oinas

Teknologiavälitteinen palaute:

opettajien käytäntöjä, oppilaiden käsityksiä, ja yhteys oppimiseen ja akateemiseen hyvinvointiin

Tiivistelmä

Teknologiavälitteisen palautteen vaikusta tehtäväsuoriutumiseen on tutkittu laajasti. Opettajan antama teknologiavälitteinen palaute oppilaalle liittyy kuitenkin usein työskentelyyn oppitunneilla, ja tämäntyyppisen teknologiavälitteisen palautteen vaikutuksesta oppimiseen ja akateemiseen hyvinvointiin tiedetään vielä hyvin vähän. Aikaisempi tutkimustieto osoittaa, että palaute voi olla oppimiselle sekä haitallista että hyödyllistä, ja että palautteen saaminen vaikuttaa kognitiivisiin ja emotionaalisiin prosesseihin, joten on tärkeää selvittää, onko nykyisin jopa päivittäin käytetty teknologiavälitteinen palaute yhteydessä oppilaan oppimiseen ja hyvinvointiin koulussa. Jotta teknologiavälitteisen palautteen hyödyistä ja haitoista saataisiin tarkka käsitys, tarkasteltiin tämän tutkimuksen neljässä osatutkimuksessa sekä opettajien käytäntöjä että oppilaiden käsityksiä hyödyntäen määrällisiä ja laadullisia menetelmiä. Tutkimusaineistot käsittelevät suomalaisissa peruskouluissa yleisimmin käytetyn sovelluksen kautta annettuja palautemerkintöjä. Tulokset ovat hyödynnettävissä myös kansainvälisesti, sillä ympäri maailmaa kouluissa on käytössä sovelluksia, jotka mahdollistavat palautteen antamisen valmiita lausekkeita käyttäen.

Tutkimuksen ensimmäinen aineisto koostui kaikkiaan 211 003 autenttisesta palautemerkinnästä, jotka saatiin tutkimuskäyttöön eräästä keskisuuresta kaupungista. Tämän aineiston analyysit raportoitiin osatutkimuksissa I ja II. Lukuvuonna 2014-2015 valmiita lausekkeita käyttäen annetut palautemerkinnät osoittavat, että opettajat antavat teknologiavälitteistä palautetta eri tavoin jopa yhden opetusryhmän oppilaille (N=7811). Käyttäytymiseen ja läksyunohduksiin liittyvä kielteinen palaute kasautui todennäköisimmin pienelle joukolle poikia sekä oppimiseensa tukea tarvitseville oppilaille. Kuitenkin selkeä enemmistö kaikesta teknologiavälitteisestä palautteesta oli myönteistä.

Toisena aineistona, osatutkimuksessa III, analysoitiin valtakunnallisesti edustava otos yhdeksäsluokkalaisten (N=2031) raportoimia teknologiavälitteisiä palautemerkintöjä. Aineisto kerättiin oppimaan oppimisen tutkimuksen yhteydessä, mikä mahdollisti palautemerkintöjen sekä oppimiseen ja akateemiseen hyvinvointiin liittyviin tekijöiden yhteyden tarkastelun. Tulokset vahvistivat ensimmäisen

aineiston havainnot siitä, että oppilaat saivat palautetta eri tavoin. Lisäksi havaittiin, että oppilaat, jotka kertoivat saaneensa runsaasti myönteisiä palautemerkintöjä, arvioivat motivaationsa, kompetenssin ja opettaja-oppilassuhteensa kaikkein parhaimmaksi. Huomiota herättävää tuloksissa oli se, että oppilaat, jotka eivät olleet saaneet teknologiavälitteistä palautetta lainkaan, arvioivat oppimisen ja akateemisen hyvinvoinnin osatekijät kaikkein heikoimmiksi.

Kolmas aineisto, jonka analyysi raportoitiin osatutkimuksessa IV, koostui haastatteluista (N=64) ja lyhyestä kyselystä (N=132) liittyen oppilaiden kokemiin teknologiavälitteisen palautteen herättämiin tunteisiin. Laadullinen analyysi osoitti, että oppilaat pitivät teknologiavälitteistä palautetta itsestään selvänä osana koulutyötä. He olivat pääosin tyytyväisiä saamiinsa palautemerkintöihin ja pitivät niitä tärkeinä tietääkseen, miten koulunkäynti sujuu. Haastetteluissa oppilaat arvelivat, että säätelemällä omaa käyttäytymistään oppitunneilla suhteessa saamiinsa palautemerkintöihin, he voivat vaikuttaa arvosanoihinsa. Lisäksi oppilaat kuvailivat lukuisia myönteisiä ja kielteisiä tunteita liittyen saamaansa teknologiavälitteiseen palautteeseen.

Yhteenvetona tämän väitöskirjan neljä osatutkimusta osoittavat, että teknologiavälitteinen palaute on yhteydessä oppilaan oppimiseen ja akateemiseen hyvinvointiin etenkin silloin, kun se liittyy käyttäytymiseen oppitunneilla ja on annettu valmiita lausekkeita käyttäen. Yhtäältä osa oppilaista näyttäisi motivoituvan teknologiavälitteisestä palautteesta, mutta toisaalta osa voi kokea turhautumista tai jopa ulkopuolisuuden tunnetta jäädessään ilman palautemerkintöjä. Siksi perusopetuksessa olisikin tärkeää kiinnittää huomiota siihen, että teknologiavälitteinen palaute tukisi kaikkien oppilaiden oppimista ja akateemista hyvinvointia tasapuolisisti.

Lopuksi esitän mallin teknologiavälitteisestä palautteesta prosessina aikaisemman teoreettisen tiedon ja tämän tutkimuksen tulosten pohjalta. Mallini ajatuksena on, että oppija voi oppia hyödyntämään saatavilla olevaa palautetta säätelemällä kognitiivisia ja emotionaalisia prosessejaan tietoisesti. Autonomisesti ja tietoisesti säädelty teknologiavälitteinen palauteprosessi on tulevaisuudessa keskeinen taito, sillä yhä useammin oppiminen tapahtuu digitaalisesti. Kehittyäkseen taidoissaan autonomiseksi ja taitavaksi, on oppilaan kuitenkin aluksi saatava tukea opettajalta.

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Without the support of my family I would have never written a doctoral thesis. I thank both my father, Hannu, and mother, Leena as examples of using effort to think critically and defend bravely what is right. This kind of knowledge cannot be reached merely by formal education. I thank my dearest sisters, Heli and Taija, for whom I have shared anxiety and work pressure, but also the joyful moments of this exciting life.

I began to study educational sciences when I, as a straightforward, causality-oriented person thought I needed some manual to understand the most adorable creature lying trustingly in my arms. During the years, I have had the privilege to follow you Pyry and Iljan, two of my most precious gifts, to grow up to be strong and right-minded young men. With you, I have finally realised that humans cannot be described by averages and simple explanations. I therefore dedicate my work to you.

Lappeenranta, October 15th, 2020
Sanna Oinas

Foreword

This study rises out of confusion. Before starting my doctoral studies and this research, I worked as a classroom teacher in basic education for almost ten years. We, as teachers, were asked to use an online platform in home-school collaboration. The commercial platform adopted in most schools could be used for informing parents and guardians about schedules and contacting parents if needed via computers and smartphones. Assessments as well as pedagogical statements about special education needs were constructed on this platform. We were told that at least the hours of absences must be marked, but no other guidelines were given for teachers. It was the teacher's pedagogical choice how this platform should be used. My greatest difficulty was in using technology-enhanced feedback that enabled the teacher to make remarks about desired or inappropriate behaviour by using predefined options.

Originally, the platform had been created for the principals of the school in order to provide a tool for planning schedules (Valkama, 2020), and for students to sign up for classes online. In a phone conversation with the platform creator, Juha Engman told me that an option to give feedback about problems was created to help teacher's report to parents about any problematic behaviour of their child. In Finland, based on law, teachers have to inform parents about inappropriate behaviour (§628/1998) and soon almost every school implemented online informing, as the platform was easier to use than traditional paper notes or phone calls. Creating a channel to communicate about something considered undesirable behaviour was not the ideal starting point for the platform use. Therefore, this new practice of receiving technology-enhanced feedback produced resistance in parents and in pupils at the beginning. Pupils created a popular social media group called *Wilma ruined my life* and parents blogged about this platform being like a criminal record. A negative image was stamped on this platform in the social media and in news broadcasts (Aalto, 2015; Helin, 2015; Heimo, Rantanen & Kimppa, 2016).

Most of the teachers I knew felt pressure about how to give technology-enhanced feedback without guidelines from school authorities. We as teachers knew that the purpose was to close the gap between home and school via technology, but it seemed to work the other way round. The platform provider called for help from a popular Finnish expert, who created instructions for positive provision of feedback (Furman, 2015). In this confusing situation, teachers started to renew local syllabuses based on the new national core curriculum. Personally, I hoped for answers from these new guidelines. However, the only lines referring to technology-enhanced feedback I found from the national core curriculum were simple statements about using technology in home-school collaboration. Nothing else.

Feedback, however, was highlighted repeatedly in the new guidelines. The role of feedback was mostly associated with assessment as follows: "*School plays a crucial role in the self-concept that pupils form of themselves as learners and persons. The feedback given by teachers has a particular significance. Versatile assessment and the provision of instructive feedback are the key pedagogical means used by teachers to support pupils' overall development and learning*" (FNAE 2016, p. 49).

As the public discussion around technology-enhanced feedback had acquired a negative tone, I felt that research was needed to study the truth behind the headlines. Firstly, my intention was to obtain an overall understanding of what kind of feedback was actually delivered via this platform. Secondly, as the nature of the new core curriculum was encouraging and highlighted the overall development of the pupil, I wanted to collect evidence whether technology-enhanced feedback actually supported the learning and academic well-being of pupils as intended by the core curriculum. This was the catalyst for my thesis.

Content

Original publications

This dissertation is a synthesis of four articles, published originally as titled below:

I   **Oinas, S**., Vainikainen, M.-P. & Hotulainen, R. (2017). Technology-enhanced feedback for pupils and parents in Finnish basic education. *Computers & Education, 108*, 59–70. https://doi.org/10.1016/j.compedu.2017.01.012.

II   **Oinas, S**., Vainikainen, M.-P. & Hotulainen, R. (2018). Is technology-enhanced feedback encouraging for all in Finnish basic education? A person-centered approach. *Learning and Instruction 58,* 12–21. https://doi.org/10.1016/j.learninstruc.2018.05.002.

III   **Oinas, S**., Thuneberg, H., Vainikainen, M.-P. & Hotulainen, R. (2020). Technology-enhanced feedback profiles and their associations with learning and academic well-being indicators in basic education. *Contemporary Educational Technology, 12, 2,* ep271. https://doi.org/10.30935/cedtech/8202.

IV   **Oinas, S**., Ahtiainen, R., Vainikainen, M.-P. & Hotulainen, R. (2020). Pupils' perceptions about technology-enhanced feedback: do smiling emojis guide self-regulated learning? *Scandinavian Journal of Educational Research.* https://doi.org/10.1080/00313831.2020.1788149.

All four studies were conducted as part of a doctoral dissertation plan designed to answer the research questions of this dissertation. In each of the studies I was the first author. In the first and second article, I have independently collected the data, conducted the analyses and wrote 90% of the manuscripts. Data for the third article were collected in collaboration with the Centre for Educational Assessment at the University of Helsinki. Analyses were conducted by the first author as well as the majority of the body of the manuscript. The fourth article was conducted largely in collaboration with Dr. Raisa Ahtiainen, who took part in the data collection and analyses. Only the theoretical section of the fourth manuscript was written solely by me. Overall, in these four articles, my share of the work has been approximately 85 percent.

1 Introduction

Research on feedback in general focuses mainly on how teachers should implement feedback in order to improve pupil's performance in a classroom task (Hattie & Timperley, 2007; Kluger & DeNisi, 1996; Shute, 2008). Likewise, research on *technology-enhanced feedback* focuses on how feedback should be delivered in computer-based environments in order to improve outcomes in a specific task (van der Kleij, Feskens & Eggen, 2015). Obviously, there is a gap in the literature in terms of technology-enhanced feedback related to learning and behaviour during the lessons.

In this study, feedback from teacher to pupils and their parents delivered via computers and smartphones in terms of learning and behaviour during the lessons is described as technology-enhanced feedback. The term *enhanced* is used to describe the nature of this particular type of feedback: it aims to improve learning and technology makes it easier to deliver. Compared to most studies about technology-enhanced feedback (Dawson, et al., 2018), what is unusual in this feedback is that teachers have an opportunity to use predefined feedback statements, just clicking on the options in order to send a remark. It is not used, moreover, to improve performance and behaviour immediately at the time an incident occurs rather the feedback, moderated by parents, is expected to help later on. In Finland, almost all municipalities have a licence to a single educational platform from a commercial provider enabling provision of such feedback. Hence, this technology-enhanced feedback is common to almost all families with school- aged children.

Feedback, when provided in the classroom, is only a moment in a continuous flow of interaction between a teacher and a pupil. Technology-enhanced feedback read through a smartphone during the daily events may also be mixed up with other messages and information from the virtual environment. Pekrun (2009) points out that feedback influences both thinking and emotional experiences during the school day. Furthermore, Boekarts (2011) warns that feedback may interrupt the processing of knowledge and set a self-protective pathway in motion. While there are numerous moments and a variety of factors besides feedback affecting learning during the school day, it may even be impossible to separate the effect or causality of the single feedback event on learning. However, when feedback is given via technology, it leaves at least some evidence that can be used to make systematic observations. It is suggested that digital data driven from educational platforms should be utilised to improve teachers' practices in order to develop evidence-based instruction (Brown & Harris, 2018; Wolf, Jones, Hall & Wise, 2014).

Provision of feedback for a pupil has become increasingly significant since the importance of formative feedback has been highlighted in education (Atjonen, 2014; Wiliam, 2014). The aim of this study is partly to provide evidence for teachers about effective feedback practices in terms of technology-enhanced feedback, since Black and Wiliam (2018) argue that although formative assessment has been emphasised for decades in education, there is still a gap in the pedagogical literature. Moreover, Vehkakoski (2020) concluded recently, that although teachers' intentions were to support pupils' attitudes for learning, they provide praise representing mainly controlling rather than autonomy supportive language, and these kinds of feedback practices were not effective. To support the development of a growing sense of independence, it is suggested that teachers should target their feedback to support pupils' self-assessment skills rather than swamping the pupil with information (Black & William, 2018; Vehkakoski, 2020). However, although assessment is in theory a significant viewpoint by which to evaluate feedback practices, this study concentrates primarily on feedback and assessment perspectives will be touched upon only briefly.

Besides the effectiveness of educational outcomes, the current educational ethos emphasises the autonomous and active role of a learner (Boud & Molloy, 2013; Miele & Scholer, 2016). Moreover, current technology enables a variety of forms, such as seeking feedback or tailoring individualised feedback even when it is automated to develop different skills, such as self-regulation or metacognition (Dawson et al., 2019; Kapsalis et al., 2019; Molin, Haelermans, Cabus, Groot, 2020; Winne 2017; Wolf et al., 2014). As the literature is limited about how pupils utilise technology-enhanced feedback in terms of the current learning paradigm that emphasises autonomous learning, this study aims to fill this gap in research.

The online platform enabling the technology-enhanced feedback studied in this thesis, has been in use for around twenty years. Thus, there may already be generations who have grown up to taking this technology-enhanced feedback as an everyday practice in comprehensive schools. If feedback is collected and recorded into an online platform year after year, it creates a digital footprint for the person. As Finnish pupils have already gathered such feedback for their digital profiles for years, it is likely that this record has some kind of a meaning to their learning, and perhaps and perhaps even their sense of identity. Partly, this research is needed to make ethically sustainable conclusions about the features of this footprint and its impact for the growing child.

Currently, there are signs of an effort to create new platforms based on the pedagogical needs of the municipalities (Helsingin Sanomat, 2019). Regarding the scientific literature, technology-enhanced feedback related to learning and behaviour during the lessons is clearly underresearched, and therefore evidence is needed in order to make choices concerning efficient practices. In the Finnish context, the dissertation at hand is the first to evaluate technology-enhanced feedback practices by teachers and pupils' perception about it. Since there are plenty of

educational platforms around the world (Hoffman, 2008; Kapsalis et al., 2019; Palts & Kalmus, 2015), the evidence of this study can be utilised to develop pedagogically appropriate platforms not only in Finland, but also globally.

The main argument of this dissertation is that technology-enhanced feedback can be a significant factor that contributes to the learning and academic well-being of pupils. Brown and Harris (2018) point out that studying feedback realiably is difficult and often methodological choices influence the findings. Therefore, the evidence for this argument will be collected with four sub-studies using three data sets analysed with mixed methods. In the first study, authentic technology-enhanced feedback notes drawn from a platform will be analysed by quantative methods in order to give an overall understanding of teachers' practices and the content of this rather unique type of feedback. Technology-enhanced feedback for pupils with special needs and pupils with no support needs are compared in the second study in order to evaluate whether all the pupils are equally supported in terms of feedback practices. In the third study, statistical relations between pupils' self-reported technology-enhanced feedback and indicators of learning and academic well-being will be analysed using a nationally representative sample. This is done as there is evidence that feedback influences both cognitive and affective factors (Boekaerts, 2011; Pekrun, 2009), thus it is likely to be connected to academic well-being alongside of learning. Finally, in order to deepen the understanding of this phenomenon, pupils' perceptions and experienced emotions in terms of technology-enhanced feedback will be studied in the fourth sub-study using qualitative methods.

The purpose of the summary of these four sub-studies is to broaden the conclusions of the results in relation to findings from earlier literature, and propose a model describing technology-enhanced feedback as a process. It is hoped that the findings and conclusions of this thesis will benefit all parties in education. Clearly this means teachers, but above all the aim is to benefit pupils.

2 Technology-enhanced feedback

As feedback has been studied in different fields of psychology for around a hundred years, there are of course multiple ways to approach the topic of this study. Studying technology-enhanced feedback, specifically in the educational context is, however, still a rather new area of research. As there is no established tradition about how to study technology-enhanced feedback, a brief overview of the literature related to different perspectives on studying feedback will first be presented in this chapter. Secondly, in order to create a deep and solid understanding of technology-enhanced feedback and its relation to learning and academic well-being of pupils, a theoretical framework is necessary. The chosen framework for this study is presented in the third chapter.

According to Schunk (2012, p. 10): "A theory is a scientifically acceptable set of principles offered to explain a phenomenon. Theories provide frameworks for interpreting environmental observations and serve as bridges between research and education." In this study, the chosen theories are in line with the values and theories behind the Finnish national core curriculum and represent a learning paradigm in which the idea of school is to support pupils' own agency as active learners (FNAE, 2016). Thus, the chosen framework builds a bridge from theoretical ideas and goals of developing learning and academic well-being to interpreting current technology-enhanced feedback practices. Bridges provide ways to walk both back and forth; interpreting the phenomena is important, but even more important would be to connect theory with practice. By choosing and testing the theory, this study aims to provide a useful theoretical framework for future work on the topic at hand.

The literature emphasises the learner's active and autonomous role in the learning process (Dawson et al., 2018; Black & Wiliam, 2018; Deci & Ryan, 2000; Henderlong & Lepper, 2002; van der Kleij, Adie & Cumming, 2019; Miele & Scholer, 2016; Ryan & Deci, 2000; Sadler, 1989; Winne & Nesbit, 2009). To support the agency of a learner, the definition of feedback should perhaps also be updated. Instead of information being poured over a passive pupil, feedback should be understood as a process where pupils seek and make sense of information to support their learning (Ashford, Blatt & VandeWalle, 2003; Carless & Boud, 2018; Boud & Molloy, 2013; van der Kleij et al., 2019; Sadler, 1989).

Feedback is dependent on the goal. In the school context, the goal of learning and behaviour vary between pupils' self-set intrinsic goals and goals set by a teacher or parents, thus affecting how feedback is given and taken. Further, the goal of education can vary between fostering an efficient employee, and supporting the growth of a self-determined individual. Somewhat surprisingly, Wiliam (2016) argues that most teacher feedback is useless, while Kluger and DeNisi

(1996) have evidence based on a large review that one third of feedback is actually detrimental to performance. Therefore, to understand the mechanism of feedback, we should start from the beginning. In this chapter, the conception and purpose of feedback during the decades of the different learning paradigms are first briefly described. The overview is limited to the main ways in which the conceptualisation of feedback has developed since its birth to the present day. Following this, literature related to the current emphases on developing beneficial technology-enhanced feedback for learning is presented.

2.1 Research on feedback from past to present

The origins of feedback are neither in education nor in educational psychology. In fact, electrical engineer Charles Proteus Steinmetz (1915) was the first to combine the words *feed* and *back* when he described the control and protection of electrical systems. In 1920, *The Oxford Dictionary* defined feedback as "the return of a fraction of an output signal to the input of an earlier stage" in relation to electronics (www.merriam-webster.com). In modern mechanics, processes are sill evaluated by studying the different qualities of feedback (e.g. Reddy, DeVor, Kapoor & Sun, 2001). Today, *feedback* has three definitions: 1) information about reactions to a product, a person's performance of a task, etc. which is used as a basis for improvement, 2) the modification or control of a process or system by its results or effects, for example in a biochemical pathway or behavioural response, 3) the return of a fraction of the output signal from an amplifier, microphone, or other device to the input of the same device; sound distortion produced by this (www.lecico.com). Thus, *feedback* has become something which is understood as part of a cyclical system in technology but also in relationships between humans.

  In scientific literature to do with human interaction, occupational psychologists were the first to be interested in feedback (Prue & Fairbank, 1981; Steptoe-Warren, 2013). Feedback was first implemented in order to improve productivity in factory assembly lines. Thus, after the global period of industrialisation, maximised productivity was the first phenomenon to be studied by feedback researchers. Frederick Winslow Taylor's theory of scientific management was published in 1911 (Steptoe-Warren, 2013; Taylor, 1911) with the goal of optimising the operations of workers on assembly lines. Soon, however, it became clear that humans were unable to work like machines, prompting Elton Mayo to begin his Hawthorne studies, which led to the founding of the *human relations movement* (Steptoe-Warren, 2013). Mayo was concerned about democracy, freedom and the social problems of the working class, and therefore his research focused on the work environment, such as lighting, rest breaks and team relationships, but also on feedback. He concluded that by developing social relationships between employees as team members and between employees and managers, productivity would also

increase. Providing praise as encouraging feedback was noticed to enhance job satisfaction, and consequently productivity (Steptoe-Warren, 2013). Today, providing feedback for employees in the working context is still largely studied under management theories and occupational psychology (for a review, see Ashford et al., 2003).

The conception of feedback was soon also applied to behavioural psychology. Burrhus Frederic Skinner, generally known as B.F. Skinner, investigated with animals to see how desired behaviour could be repeated by reinforcing it either with pleasant or unpleasant consequences (Skinner, 1938). He wrote, "*the consequences of behavior may "feed back" into the organism. When they do so, they may change the probability that the behaviour, which produced them will occur again. The English language contains many words, such as "reward" and "punishment," which refer to this effect*" (Skinner, 1953, p. 59). Sidney Pressey also studied reinforcement and was perhaps one of the earliest researchers who tried to develop technology-enhanced feedback by inventing a device for automatic scoring as early as 1915 (Kulik & Kulik, 1988; Pressey, 1950).

Learning, such as memorising, thinking and feeling had been studied under behavioural psychology since the late 19th century (Taylor, 2001). In the beginning of the 20th century, Edward L. Thorndike and John Dewey, who represented different schools of psychology, both argued that education should follow research-based evidence on learning (Schunk, 2012). Later, Skinner showed that there was a clear measurable link between stimuli and reactions, leading to his conditioning theories and those of other behavioural psychologists, such as Watson, Thorndike, Pavlov and Guthrie. Together they formed a central framework in the learning paradigm of behaviourism that used quantitative methods in education (Kulhavy & Stock, 2001; Schunk, 2012).

Although it took decades before psychological research evidence about learning and teacher's methods of instruction overlapped, the notion of *feedback* was soon applied in education (Schunk, 2012). The linguist John Trim (1959, p. 67) was probably the first to apply *feedback* in the educational context: "*the live speaker has a reaction, a 'feed-back' from the listeners, and if he develops a sensitivity, he can adjust his speech accordingly*". Interestingly, a study related to technology-enhanced feedback in education was published as early as 1968 (Hall, Adams & Tardibuono, 1968).

During the paradigm of behaviourism, the external feedback about external behaviour as a form of reinforcement was understood as a powerful tool to reach learning goals (Kulhavy & Stock, 1989). Behaviourism was challenged by the need to understand human mental processes, and eventually the development of cognitive approaches took place in psychology and education. Jean Piaget's theories of cognitive development (Inhelder & Piaget, 1958) and Lev Vygotsky's sociocultural theory developed in the 1920s (Vygotsky, 1978) constituted the constructivist paradigm of learning. Later, Albert Bandura's social learning theory

from the 1960s developed into the social cognitive theory by the 1980s, the key argument being that learning was mostly regulated by the learners' own volition in reciprocal interaction with peers and significant adults. What all these theories had in common was that the aim of feedback was not only to provide information to reduce the gap between current level and desired level of behaviour (Kulhavy & Stock, 1989) but also to encourage the learner to believe in his or her abilities (Bandura, 1977; Butler & Winne, 1995). In 1989, Kulhavy and Stock argued strongly that feedback cannot be studied only as a straightforward stimulus between pre and post outcomes while providing feedback in the middle. Thus, the impact of feedback on learning has been studied often with quantitative methods from various perspectives, such as social support (Rowe, Fitness & Wood, 2013; Tennant, Demaray, Malecki, Terry, Clary, & Elzinga, 2015), engagement (Klem & Connel, 2004) and school adjustment (Reddy, Rhode & Mullhal, 2003). Moreover, qualitative methods, such as discourse analysis describing initiation-response-feedback sequences have been used to study teachers' initiation, learners' response and teachers' feedback in classroom settings (Heap, 1988).

Throughout the history of psychology and education, there have been different traditions when studying human nature and learning (Taylor, 2001). Humanistic psychology, which has been said to form the basis for current positive psychology, has offered an alternative approach and has highlighted supporting the learner's autonomy in education (Rauhala, 1990; Taylor, 2001). As early as 1899, psychologist William James wrote guidelines for teachers emphasising the importance of encouraging and supporting pupils (Taylor, 2001). In the 1960s, William Glasser provided a theory that highlighted the learners' need for choice and social support (Cassell & Nelson, 2013). He argued that management based on rewards and punishments does not belong in education and emphasised that encouraging feedback from a teacher, and trusting in a student's ability and agency to fulfil his goals were essential to learning (Cassell & Nelson, 2013). Furthermore, Carl C. Rogers transferred person-centred teaching and a positive regard between teacher and pupil from psychology to schools, seeing it as a starting point for child-centred education (Rogers, Lyon & Tausch, 2014; Taylor, 2001). Child-centredness is a corner of the current learning paradigm in Finnish basic education.

Starting from the 1960s feedback has been associated with constructing an inseparable part of formative assessment, meaning that assessment should provide information to support the learning process rather than only providing final grades of the learning outcome (Bloom, 1969; Wiliam, 2014). However, it was not until 1989 that D. Royce Sadler brought the concept of feedback into broader educational research discussions (Carver, 2017; Sadler, 1989). Sadler argued that feedback is a key element in formative assessment, which consists of both external information about learning and learners' self-monitoring (Sadler, 1989). To *form* learning in order to achieve a desired goal, *formative* feedback was needed, rather

than just *summing up* the outcomes by *summative* judgement (Sadler, 1989). Still, however, feedback was associated with occupational psychology and defined according to management theory in which productivity was emphasised (Ramaprasad, 1983; Sadler, 1989), although in the 1970s the effort to study the connections between feedback and learning in educational contexts already existed (Kulhavy & Stock, 1989). Sadler (1989) stressed that feedback should reduce learners' dependency on the teacher and should provide knowledge about how to develop skills to self-monitor the learning process. According to Sadler (1989, p. 142), appropriate feedback consists of "*knowledge of the standard or goal, skills in making multicriterion comparisons, and the development of ways and means for reducing the discrepancy between what is produced and what is aimed for.*"

After Sadler's (1989) definition of feedback, several further definitions in education focused on improving learning (e.g. Brookhart, 2011; Butler & Winne, 1995; Shute, 2008; Patchan & Puranik, 2016; Wiliam, 2011). One of the most cited comes from Hattie and Timperley (2007), who define feedback as "*information provided by an agent (e.g., teacher, peer, book, parent, self, experience) regarding aspects of one's performance or understanding*". Moreover, there is a consensus that the purpose of feedback should be to provide information on how to improve performance in order to close the gap between the current and the desired level of learning (Hattie & Timperley, 2007; Hughes, 2010). According to the latest understanding, feedback should be provided *for* learning, not *of* learning (Wiliam, 2014), meaning that feedback should give suggestions about how to continue. Instead of final judgements about achievement or a product, feedback should provide information about how to work towards an intended level of learning (Hattie & Timperley, 2007). Moreover, Black and Wiliam (2018) suggest that *feedforward* describes better information that fosters future learning. Henderlong and Lepper (2002) argue that if the aim is to support the development of autonomous learners, then children should not be encouraged to seek the approval of the teacher as a form of feedback or praise in the first place.

The aim of this brief introduction on the history of feedback was to provide insights into different research traditions to understand the situation today. Overall, the history and development of feedback could be summarised by the following opposing perspectives. 1) At first, the purpose of feedback was to control productivity and behaviour by providing professional feedback to reach top performance. 2) Later, the importance of supporting the autonomous learning process by providing feedback as part of formative assessment has been emphasised. The heritage of these opposing viewpoints can still be seen; in organisational psychology the emphasis is on defining the most effective way of providing feedback (Hermsen, Frost, Renes & Kerkho, 2016; Van Dijk & Kluger, 2010) and in educational psychology the purpose of defining the best feedback practices is to support the development of the self-directed learner (Boud & Molloy, 2013; Winne,

2017). Most recently, instead of *providing* effective feedback, educational researchers have started to think that perhaps it would be best for the learning process if a learner seeks feedback her/him selves when s/he considers feedback is needed (Boud & Molloy, 2013). However, the idea of feedback seeking comes originally from management and organizational psychology (Timmers, Braber-van den Broek, & van den Berg, 2013), where employees seeking feedback have been studied since 1983 (Ashford et al., 2003). In addition to the human autonomous need to seek feedback, Ashford and colleagues (2003) point out the need for encouragement and positive feedback about individual strengths as a valuable source to foster well-being. They also suggest that different psychological disciplines should be united to study feedback and take advantage of each other's perspectives (Ashford et al., 2003).

2.2 Overview of perspectives when studying feedback

As feedback has been studied in educational contexts for decades, several reviews have been compiled, such as Kulik and Kulik (1988), Kulhavy and Stock (1989), Kluger and DeNisi (1996), Shute (2008), Fong, Patall, Vasquez and Stautberg (2019). Dawson and colleagues (2018) provide a summary of research on feedback in technology-enhanced conditions at school. The conceptual framework of feedback and learning has been presented by Sadler (1989), Butler and Winne (1995), Narciss and Huth (2004), Hattie and Timperley (2007), Shute (2008), and Boud and Molloy (2013), for instance.

Most of the studies evaluate the relations of feedback and learning in empirical settings where the effect of feedback on learning has been measured by comparing the outcomes before and after receiving feedback (Kulhavy & Stock, 1989; van der Kleij et al., 2015). Often feedback is classified as either giving information about whether the response is correct or incorrect as a verification, or information that has a more elaborative nature by providing, for example, an explanation for the solution (Kulhavy & Stock, 1989; Narciss & Huth, 2004; Shute, 2008). The effect of feedback has also been studied in conditions where learners are told in advance that they will receive feedback after having completed a task (Deci, Koestner & Ryan, 1999; Pekrun, Cusack, Murayma, Elliot, & Thomas, 2014).

Feedback can be given orally, visually or in a written form for instance. It can be given during a learning task immediately or afterwards, as delayed. Some teachers may think that feedback is enough when said once, but others may provide feedback frequently. To find the most effective way of implementing feedback, there are various details, such as content, target, modality, frequency, duration, usability and visual attraction that can be studied in relation to feedback

(Brookhart, 2013; Hermsen et al., 2016; Shute, 2008). In addition, there are perspectives that aim to create a broader understanding of mechanisms, such as feedback and adopted mindset (Dweck & Master, 2009), feedback and self-regulation (Butler & Winne, 1995), feedback and motivation (Reeve, Ryan, Deci & Jang, 2009), and feedback and self-esteem (Harter, 2012) for example. Not just *given* feedback is studied, but also feedback that is sought by the learner (Ashford et al., 2003). Although other classifications exist, Narciss and Huth (2004) conceptualised three perspectives that can be taken into account when designing feedback: 1) *content* as hints and explanations, 2) *function* as cognitive or motivational, and 3) *presentation* as timing and frequency.

Below, Table 1 provides examples of perspectives that are meaningful for educational research with their main findings. The aim is to create a brief overall understanding of the literature describing the aspects of feedback studied. Studies have not been chosen by systematic review. Instead, they represent the variety of perspectives that exist in terms of studying feedback related to learning (Brookheart 2013, Hermsen et al., 2016; Shute, 2008). There are of course more perspectives than those presented in the table. The perspectives chosen as central to this thesis are presented more specifically in the third chapter.

Table 1. Perspectives on studying feedback in education.

Authors, year, title	Perspective	Focus	Findings
Butler & Winne (1995): "Feedback and self regulated learning: A theoretical synthesis."	Self-regulated learning	Conceptual analysis	Adopted knowledge, beliefs and the goals of the learner have an effect on how external feedback is experienced and utilised. Feedback has an effect on cognitive engagement and thus the authors propose a model of feedback mediating self-regulated learning.
Cutumisu & Schwartz (2018): "The impact of critical feedback choice on students' revision, performance, learning, and memory."	Seeking of feedback	N=106, 13 to 14-year-old pupils	Critical technology-enhanced feedback benefitted learning if the learner had chosen to seek feedback, but a detrimental effect emerged if the feedback was delivered without asking for students' willingness to receive it.
Dawson et al., (2018): "Technology and feedback design."	Technology-enhanced feedback	Literature review of 27 articles	Technology, such as e-portfolios, may support feedback processes by enabling a more effective use of feedback. Feedback as a conversational process could be developed by using a semi-intelligent recommender as a sophisticated technology.
Dawson et al., (2019): "What makes for effective feedback: Staff and student perspectives."	Effectiveness	University students	Based on inductive thematic analysis, both students (N=4514) and teachers (N=406) thought that feedback should be given to improve learning. Students perceived that detailed and personalised feedback was useful.
Deci et al., (2001): "Extrinsic Rewards and Intrinsic Motivation in Education: Reconsidered Once Again."	expected/unexpected, informational/controlling	Meta-analysis of 128 studies	If verbal rewards as positive feedback are perceived as informational it supports intrinsic motivation (d=0.66) but if it is controlling then praise decreases intrinsic motivation (d= − 0.44). Expected rewards will decrease intrinsic motivation. Unexpected rewards have no effect on intrinsic motivation.
Dweck & Master (2009): "Self-theories and motivation, students' beliefs about intelligence."	Target	Theoretical synthesis	Person-targeted feedback affects adopting a fixed mindset. Process-targeted feedback impacts adopting a growth mindset and is beneficial for learning.

Authors, year, title	Perspective	Focus	Findings
Fong et al, (2019): "Meta-analysis of negative feedback on intrinsic motivation."	Motivation	Meta-analysis of 78 studies	Compared to positive feedback, negative feedback decreased intrinsic motivation overall. Compared to no feedback conditions, negative feedback had no effect. Criterion-based, constructive and detailed criticism may even improve motivation.
Griffin (2018): "Using assessment feedback for motivation among early adolescents: A grounded theory study."	Self-determination	4 teachers and 30 10-year-old pupils	Interviews, questionnaires and classroom observations revealed that descriptive feedback as formative assessment had an influence on pupils' perceived competence, relatedness and motivation. Evaluative feedback may lead to amotivation.
Hattie & Timperley (2007): "The power of feedback."	Content	Summary of the 12 meta-analyses	Four levels of feedback: 1) information about task (correct/incorrect), 2) targeted to learning process, 3) supporting self-regulation, 4) targeted to the person.
Hepplestone et al., (2011): "Using technology to encourage student engagement with feedback: A literature review."	Engagement	Literature review, university level	Technology-enhanced feedback, such as statement banks, were found to be both effective and weak to support engagement and learning. Predefined statements should be referred to students' work individually in order to be effective.
van der Kleij et al., (2015): "Effects of feedback in a computer-based learning environment on students' learning outcomes: A meta-analysis."	Effectiveness	Meta-analysis of 40 studies	Elaborative feedback had a positive albeit moderate effect on task outcomes. The effect of feedback about correct response was extremely small. No effect between outcomes and timing of feedback was found.
Kluger & DeNisi (1996): "The effects of feedback interventions on performance: A historical review, a meta-analysis, and a preliminary feedback intervention theory."	Task-performance, individual differences	Meta-analysis of 607 effect sizes and 23,663 observations	Only two thirds of feedback interventions improve performance. Feedback intervention theory synthesised based on meta-analysis suggests that feedback may change the locus of control, thus interrupting performance, especially if the feedback is perceived as targeted to the self. Four strategies to cope with feedback are presented.

Authors, year, title	Perspective	Focus	Findings
Kulik & Kulik (1988): "Timing of feedback and verbal learning."	Timing	Meta-analysis of 53 studies	With the acquisition of items, such as a list of words, immediate feedback is suggested. In laboratory settings, delayed feedback may also be beneficial.
Lim et al., (2019): "What changes, and for whom? A study of the impact of learning analytics based process feedback in large course."	Complexity, Self-regulation	University students (N=784)	Process-targeted feedback design based on analytic-data of the regulation of learning strategies improved performance compared with a control group with no feedback.
Molin et al., (2020): "The effect of feedback on metacognition – A randomized experiment using polling technology."	Metacognition	University students (N=633)	Compared to the control group, peer discussions and formative face-to-face feedback from teachers is beneficial for developing metacognitive skills when students used a computer-based learning environment.
Pekrun et al., (2014): "The power of anticipated feedback: Effects on students' achievement goals and achievement emotions."	Anticipation of process vs. normative fb	High school students (N=153)	Anticipating process-targeted feedback impacted on adopting a mastery goal. Anticipating normative feedback impacted on adopting a performance goal or a performance avoidance goal. Goals mediated the impact of feedback on emotions.
Ritzhaupt & Kealy (2015): "On the utility of pictorial feedback in computer-based learning environments."	Pictorial feedback	University level (N=132)	Results showed no difference between written feedback and feedback delivered with semantically related pictures in a computer-based reading comprehension task.
Rowe et al., (2014): "The role and functionality of emotions in feedback at university: A qualitative study."	Emotions	University level (N=15 teachers, 21 students)	Students thought that both encouraging and critical detailed feedback are needed in order to learn. Students thought that individualised feedback from a teacher is a sign of a teacher's care and support. Students felt gratitude if they received detailed feedback or anger when the feedback was felt to be irrelevant.

Authors, year, title	Perspective	Focus	Findings
Schunk (1984): "Sequential attributional feedback and children's achievement behaviors."	Ability/effort	2 x 40 8 to10 –year-old children	Feedback targeted to abilities increased ability attributions and higher performance. Repeated feedback targeted to effort may be understood as related to lower abilities, thus it may decrease self-efficacy beliefs.
See et al., (2016): "Teachers' use of research evidence in practice: A pilot study of feedback to enhance learning."	Teachers' feedback practices	9 treatment schools on the primary level	Results showed that it was difficult for teachers to implement evidence-based feedback according to Hattie & Timperley (2007). Feedback intervention (N=1,677) compared to performance of the control group (N=1,174) had no effect.
Shute (2008): "Focus on formative feedback."	Quality, content, timing	Literature review (N=141) & synthesis	Formative feedback should be nonevaluative, supportive, elaborative and individualised. Pupils need to be willing to receive feedback in order to be effective. Feedback should not interrupt learning nor be normative.
Tennent et al., (2015): "Students' ratings of teacher support and academic and social–emotional well-being."	Feedback related to behaviour	Middle school students (N=796)	Teachers' informational support, such as feedback about behaviour was related to lower achievements. Emotional support, such as care of pupils' well-being was related to higher achievements and better school adjustment.
Wulf et al., (2010): "Frequent external-focus feedback enhances motor learning."	Frequency	48 10 to 12-year-old children	High frequency of feedback was connected to higher performance compared to the control group receiving feedback less frequently when rehearsing soccer.
Zumbrunn et al., (2016): "Toward a better understanding of student perceptions of writing feedback: A mixed methods study."	Self-efficacy beliefs	N=598 middle and high school students	Self-efficacy beliefs influenced whether students liked receiving feedback; students with lower perceptions about their skills did not want to receive feedback.

2.3 **Technology-enhanced feedback in educational research**

To describe technology-enhanced feedback, technology should first be defined. In this study, the definition is limited to devices or platforms used currently in educational contexts. Furthermore, research on technology-enhanced feedback that is reviewed in this chapter is limited to the context of education or educational psychology. Moreover, the literature is limited to studies evaluating the impact of technology-enhanced feedback on pupils' learning in primary or secondary education, or students in upper levels of education, although there are also numerous studies about technology-enhanced feedback given to teachers in educational contexts as well. Overall, it should be remembered that most studies related to technology-enhanced feedback are still conducted in the fields of engineering or health and well-being in order to study disruption or change in habitual behaviour by providing technology-enhanced feedback (Hermsen et al., 2016).

While the feedback is defined as an interactive and dialogic process between the source of information and a learner (Boud & Molloy, 2013; Dawson et al., 2018), then, technology-enhanced feedback could be defined as a process where information is sought or delivered through a technology in order to enhance learning. In other words, learners can actively seek information by themselves from the technological environment to support their learning or understanding. However, technology-enhanced feedback is still usually understood as an information *given* to a learner via technology in order to improve learning outcomes (Van der Kleij et al., 2015). Computer software, for example, can be programmed to give feedback about progress during the game or learning tasks taken via some mobile application. Alternatively, learning analytics can be merged together with augmented reality in order to design personalised feedback on virtual experience. Furthermore, eye-trackers or hearing aid technology could be brought into use when implementing feedback, for instance.

Although there already are some innovative technology-enhanced feedback designs (Lim et al., 2019; Noroozi et al., 2019; Timmers et al., 2013), in the end, perhaps the most usual case is that by using various educational platforms, teachers provide technology-enhanced feedback, which could be compared to paper-based written feedback or feedback given to learners. This claim receive support from a recent literature review of research about technology-enhanced feedback in education. In their study, Dawson and colleagues (2018) identified four categories of technology-enhanced feedback: 1) *educator to student feedback*, where a computer is used as an assistant when a teacher provides feedback to a student in a distant learning context, 2) *computer to student feedback*, meaning automated feedback or intelligent tutor systems, 3) *peer to student feedback* using interactive platforms, and 4) *self-feedback*, such as e-portfolios. In the first category *educator to student feedback*, there were 521 studies while in other categories they found only 21 to 55 studies (Dawson et al., 2018). Moreover, Henderson and Phillips

(2014) argue that perhaps video recordings from a teacher are the most effective technology-enhanced feedback as it provides opportunities for feedback dialogue compared to face-to-face feedback. However, overall in the educational literature there are still a relatively small number of studies available related to technology-enhanced feedback. Lai and Bower (2019) found in their systematic review that in recent years only 3% of studies evaluating the use of technology in education concerned feedback. Nevertheless, a search in the journal pages of *Computers & Education* with the term *feedback* resulted in 2,487 articles published between 1996 and 2020. Van der Kleij and colleagues (2015), however, have published a meta-analysis drawing conclusions about the effect of timing and type of technology-enhanced feedback delivered during a computer-based learning task. Interestingly, the oldest publication included in their analysis was conducted as early as 1968. In this study Hall and colleagues (1968) investigated the effectiveness of computer-assisted feedback about incorrect responses in a task created to learn geographical vocabulary. In the higher education context, there has been an effort to develop technology-enhanced feedback (Hepplestone et al., 2011). According to Hepplestone and colleagues (2011), the recorded statement banks created were related to assessment and grading, thus they hardly provided information that would improve learning.

In the educational context, technology-enhanced feedback is also a way to keep in touch with parents and guardians (Kuusimäki, Uusitalo-Malmivaara & Tirri, 2019; Palts & Kalmus, 2015). When computers and mobile phones became common, e-mails, text messages and online chats were first used to provide technology-enhanced feedback (Hu, Wong, Cheah, & Wong, 2009; Juniu, 2009; Shayne, 2008; Thompson, 2008; Thompson, Mazer & Grady, 2015). Later, smartphones have enabled the development and use of online platforms and applications.

There is discordant evidence in the literature about the benefits of technology-enhanced feedback on learning (van der Kleij et al., 2015). Although Dawson and colleagues (2018) were rather sceptical based on their review whether current designs of technology-enhanced feedback actually benefit learning, Lim and colleagues (2019), found that technology-enhanced personalised feedback based on learning analytics supported university students to maintain their attention during the semester and study more regularly. Moreover, they reported that students receiving technology-enhanced feedback performed better than a control group with no feedback intervention (Lim et al., 2019). Van der Kleij and colleagues (2015) concluded, based on their meta-analysis, that the more detailed the technology-enhanced feedback was, the larger effect it had on learning outcomes, especially if the task required higher-order thinking. Information about correct or incorrect response hardly had any effect on learning outcomes (van der Kleij et al., 2015). Timmers and colleagues (2013) found that a learner's motivational characteristics and task appraisals moderated whether the technology-enhanced feedback actually benefitted learning. They detected positive connections between feedback-

seeking behaviour and students who evaluated themselves as willing to use effort in computer-based tasks, but there were also connections between feedback avoidance and students with ego-protective goals (Timmers et al., 2013). Cutumisu and Schwartz (2018) also found evidence that students' willingness to receive and seek feedback affected whether technology-enhanced feedback was useful or harmful for learning. In addition, Attali and van der Kleij (2017) found oppositional results about the value of technology-enhanced feedback. They showed the relevance of feedback design, as surprisingly, the usefulness of the content and the timing of the feedback was dependent on whether a student answered the first question correctly in their computer-based test (Attali & van der Kleij, 2017). Thus, more evidence related to technology-enhanced feedback is needed to draw conclusions.

2.4 Technology-enhanced feedback as formative assessment

In the school context, assessment is defined as "the process of gathering and interpreting evidence to make judgements about the quality of pupils' achievement (Atjonen, 2014, p.1)". Nowadays, in Finnish comprehensive school two types of assessment, *summative* and *formative* are used. While summative assessment usually means a final judgement or rating of a pupil's knowledge, the aim of formative assessment is also to support the learning process in the future. As there is a consensus that feedback should also be provided to support the learning process, feedback can be seen as part of formative assessment. Compared to summative feedback about final scores in a task for instance, the aim of *formative feedback* is to provide information in order to support the learning process of a pupil (Shute, 2008). In fact, in terms of formative feedback, *feedforward* would probably describe the meaning of feedback better (Black & Wiliam, 2018). Shute (2008) also reminds us that feedback that has a negative effect on learning is never formative in nature. This should be kept in mind, as the literature indicates that one third of feedback is harmful for learning (Kluger & DeNisi, 1996). As providing feedback for a learner is usually mentioned as being an important part of formative assessment (Black & Wiliam, 2018; Shute, 2008), the role of feedback in education has increased over the decades.

In Finnish schools, providing formative feedback became topical at the latest in the 1990s when a turn in assessment from categorising pupils based on their outcomes to supporting pupils' own assessment skills in order to develop skills for future life was introduced into the national core curriculum (Mäensivu, 1999). This was critically important, as Fong and colleagues (2019) concluded, based on their meta-analysis, that normative feedback comparing pupils to each other is detrimental for motivation. According to the Finnish Basic Education Act

§628/1998, "*The aim of pupil assessment is to guide and encourage learning and to develop the pupil's capability for self-assessment.*" Although, teaching at the basic education level is regulated by the Finnish National Agency of Education (FNAE), the national core curriculum provides relatively loose norms for teachers about what they should teach and how they should act in the classroom. As teachers get their qualification with a master's degree from a university, schools and teachers in Finland are trusted to make their own pedagogical choices. The core curriculum defines mainly the values, learning paradigms and goals for assessment. Thus, it is expected that teachers may also implement technology-enhanced feedback on the way they see it useful.

Based on the national core curriculum, learning, working skills and behaviour are assessed with a grade, in other words as a criterion-based summative assessment. The grading of a single subject consists of evaluating the achieved goals of learning along with the working skills acquired. The behaviour of a pupil is assessed with a separate grade and according to the core curriculum, pupils' individual characteristics must not influence the evaluation, although there is evidence that this is not followed in practice (Mullola, 2012). Most of the assessment should be formative in nature and should thus support the pupil's learning process. The role of feedback is highlighted as follows: "*The school plays a crucial role for the self-concept the pupils form of themselves as learners and persons. The feedback given by teachers has a particular significance. Versatile assessment and the provision of instructive feedback are the key pedagogical means used by teachers to support the pupils' overall development and learning*" (FNAE 2016, p. 49). According to Atjonen (2014), Finnish teachers are often worried that they are either too critical or too optimistic when they assess their students. Moreover, they feel the pressure to balance between positive and negative feedback (Atjonen, 2014).

The conception of learning in the Finnish national core curriculum is built upon the idea of a pupil as an active actor. Formal education is seen as an inseparable factor in developing a flourishing society. Encouraging and versatile formative feedback is emphasised throughout the core curriculum to support the development of self-image, self-efficacy and self-esteem as a learner but also as a person. It is highlighted that "*Encouraging guidance received during the learning process reinforces the pupils' trust in their potential*" (FNAE, 2016, p. 16). In the core curriculum, encouraging feedback is also seen to influence the pupils' interest and goals that they set for their learning. A recent meta-review of van der Kleij and colleagues (2019) showed that the shift from a teacher-centred to a learner-centred perspective has already been adopted in the research literature describing feedback. Whether a learner-centred perpective can also be seen in teachers' technology-enhanced feedback practices should therefore be studied as well.

2.5 **Learners' perceptions of technology-enhanced feedback**

There are at least a few studies about learners' perceptions of technology-en-hanced feedback (Henderson & Phillips, 2014) and some about feedback received (van der Kleij et al., 2015) or sought through technology (Cutumisu, 2019). How-ever, most of the studies of learners' perceptions of feedback still concern tradi-tional paper-based feedback or feedback given face-to-face. Furthermore, most studies evaluating learners' conceptions about feedback are conducted among uni-versity students, confirming the gap in research related to younger pupils' percep-tions about technology-enhanced feedback.

On the primary and secondary school level, however, at least Harris, Brown and Harnett (2014) have studied conceptions and experiences of 9- to 15-year-old children about feedback. According to their results, the majority of pupils were willing to accept feedback from their teachers, although some pupils rejected it. Moreover, they concluded that pupils perceived feedback mostly as an encourag-ing effort from the teacher to improve their work (Harris, et al., 2014). Most of the feedback was delivered along with the teacher-centric assessment, such as test cards (Harris et al., 2014).

Peterson and Irving (2008) have studied the conceptions of 11- to 13-year-old pupils by interviewing them about feedback given with assessment. The pupils perceived feedback to be most relevant for them if it contained clear suggestions about how to improve performance and what to do next (Peterson & Irving, 2008). If the feedback did not have these elements, the pupils considered it to be irrele-vant (Peterson & Irving, 2008). Recently van der Kleij (2019) has also reported the perceptions of 12- to 16-year-old pupils. It was noticed that pupils did not always understand the feedback received from their teacher and hence it was often perceived as unuseful (van der Kleij, 2019).

At the university level, students' perceptions seem to follow the conceptions of younger learners, as university students also appreciate feedback providing in-formation about how they can improve and develop their learning (Carless, 2006; Ferguson, 2011). In a large-scale data by Carless (2006), university students (N=1,740) felt that they received less feedback than their teachers thought they gave. Moreover, students wished to receive feedback about general issues so that they could use feedback to improve their work in future assignments (Carless, 2006). Often students perceived that feedback was not useful or understandable and sometimes it was even unfair, although they did wish to receive it more often (Carless, 2006).

Carver (2016) concluded that although university students mainly perceive feedback as positive, they also consider their learning to be something private and therefore they are unwilling to dialogue while receiving face-to-face feedback from their teacher, partly because of the perceived power structure between stu-dents and teachers. In addition, Ferguson (2011), Harran (2011) and Carless

(2006) reported that students experienced a variety of both pleasant and unpleasant emotions related to feedback depending on whether their perceived they had succeeded or failed in the assignment (Carless, 2006). To maintain their confidence as a learner, students emphasised the importance of the balance between encouraging and critical feedback (Ferguson, 2011). Thus, technology-enhanced feedback could perhaps provide an emotionally more secure method to receive and reflect on feedback privately at first, preparing them to discuss the issues face-to-face later if needed. In a longitudinal study about the effect of feedback on writing, Harran (2011) noticed that only 10% of the students did nothing after receiving feedback, and the rest of the students worked to improve their performances. However, only around 12% of students asked help from the teacher face-to-face after revising their work after written feedback (Harran, 2011).

2.6 Technology-enhanced feedback in home-school collaboration

Although feedback from a teacher is mainly targeted at the pupil, it also has importance to parents and guardians (Kuusimäki et al., 2019; Swick, 2006). An effort used to create a solid foundation for parent-teacher collaboration also benefits a pupil (Hirsto, 2010; Lv, Zhou, Guo, Liu, Liu & Luo, 2016). Constructive collaboration between home and school improves the pupil's academic outcomes (Hoover-Dempsey, Walker, Jones & Reed, 2002; Seitsinger, Felner, Brand & Burns, 2008; Shayne, 2008), adjustment to school (Seitsinger et al., 2008), and even the emotional well-being of pupils (Lv et al., 2016). In their study, Lv and colleagues (2016) showed that the more parents communicated with teachers, the higher the moderating effect was between learning outcomes and positive emotions among 10- to 12-year-old pupils.

The use of technology may have made it easier to the parents to keep contact with a teacher, as Thompson and colleagues (2015) reported that parents found it more convenient to discuss with a teacher via technology than face-to-face, although teachers may avoid the use of technology when there are difficult issues to handle (Juniu, 2009; Thompson, 2008). However, based on Finnish news and social media, teachers do also provide technology-enhanced feedback about difficult topics, at least in terms of behaviour (Aalto, 2015; Helin, 2015). As there is research evidence that continuous negative feedback harms the development of trustful collaboration (Mautone, Lefler & Power, 2011), it should be studied whether this negative image created by the media is true or false. Sormunen, Kirilina, Goranskaya and Tossavainen (2018) have evidence that Finnish parents are mostly contented about home-school interaction, although they do not always clearly understand the teacher's communication. Moreover, Kuusimäki and colleagues (2019) concluded recently that although the communication between parents and teachers via technology-enhanced platforms is mainly successful, there

are also parents who are not pleased about the technology-enhanced feedback received from a teacher. It is supposed that moving from only informative messaging between teachers and parents towards a more open collaboration as equal partners would benefit learning (Hirsto, 2010; Korhonen, 2017). A model for digital partnership (Korhonen, 2017) developed in the Finnish context suggests that the motivating collaboration between teachers, parents and pupils is built by using a participatory approach that relies on shared interests and goals.

2.7 Defining technology-enhanced feedback in this study

Technology-enhanced online platforms, often created and marketed by commercial companies, were gradually taken into use with home-school collaboration in Finnish basic education around 2000. Besides the most usual platform called Wilma, there are some smaller providers, such as Helmi. In a short time, the opportunity to provide feedback via computers and smartphones to pupils and their parents was adopted in most schools in Finland. Although the platform has a variety of features, only short and predefined feedback messages, called notes, are studied in this thesis. The predefinition of notes means that the administrator of the platform has created options and teachers can easily provide feedback just by clicking the options whenever they consider that feedback is necessary.

The administrators of municipalities have the autonomy to create options, resulting in a variety of different feedbacks between schools. The data here showed that there are at least options to deliver short positive comments, like "active attendance" or a smiling emoji, in addition to remarks related to forgotten homework or books. Moreover, data revealed that there are also options for disturbing behaviour. However, the teacher always has the opportunity to supplement the given feedback notes by adding something; thus, besides the predefined content of the feedback, a pupil may receive freely written clarification. Most of the feedback notes were delivered without clarifications. Hence, the information provided by technology-enhanced feedback notes could be conceptualised both as verification and as elaborative in nature. However, this type of feedback is hardly comparable to any literature of feedback. Furthermore, there is also variation in the policies about how and when pupils may have access to the platform. Some of the pupils get information from parents when they go home, but some pupils can read feedback notes themselves during the school day. Therefore, some of this feedback should be conceptualised as delayed, and some as immediate, thus affecting the experiences during the moments of learning.

Initially, there were no guidelines for teachers about how often and in what situations they should provide technology-enhanced feedback, and therefore the variation in terms of teachers' feedback practices is understandable. Thirty years ago Sadler (1989, p.134) pointed out that: *"the number of comments and their*

content depends upon the willingness of the teacher (and the time available) to actually make the comments, the ability of the teacher to express the feedback in words, and the ability of the student to interpret the comments." Based on the public discussion in relation to this technology-enhanced feedback provided by Finnish teachers, it seemed that usually the content of the feedback was about behaviour or homework. This hypothesis receives support from the fact that legislation requires teachers to keep in touch with parents and guardians in cases of absence and inappropriate behaviour (§628/1998).

Compared to the research literature on feedback, the current study is rather unique. It is also more difficult to conceptualise as the earlier evidence of feedback is most often related to task-performance conditions in which the control and intervention groups are clearly marked within a designed framework. As there are no earlier studies about this type of technology-enhanced feedback, a strict definition cannot be provided in advance. Thus, in order to create an understanding of the phenomena at hand, the literature providing evidence of the relations of technology-enhanced feedback between learning and the academic well-being of pupils is next presented.

3 Technology-enhanced feedback, learning & well-being

Around a hundred years ago, Vygotsky was concerned that intellectual thinking and motivational and emotional processes were generally seen as separated (Shute, 2008; Vygotski, 1979). Today, literature on feedback emphasises an understanding of both the cognitive and the affective dimensions in implementing feedback (Butler & Winne, 1995; Kluger & DeNisi, 1996; Narciss & Huth, 2002; Shute, 2008). In everyday life most phenomena are intertwined, creating complex networks. Moreover, learning as a cognitive factor, and academic well-being as an affective factor, go hand in hand in everyday schoolwork, both mediated by feedback but also by several other indicators, such as the learners' engagement or family conditions, which are often impossible to take into account. Shute (2008) claims that although there are a variety of studies about the connections of feedback to learning, the results are still ambiguous. Kulhavy and Stock (1989) argue that too often studies about feedback have been too simple and straightforward, only detecting improved performance by measuring pre and post outcomes with feedback in the middle. Moreover, Ashford and colleagues (2002) call upon different fields of psychology to combine their forces to understand the effects of both constructive criticism and encouraging feedback on learning. Hence, this study aims to understand both the cognitive and emotional aspects of a pupil who receives technology-enhanced feedback from a teacher.

The framework of self-regulated learning combining the cognitive, motivational and emotional aspects of learning is used in this study to provide lenses through which learning and academic well-being in relation to technology-enhanced feedback can be observed. Schunk (2012) argues that learning theories are improved by incorporating ideas from earlier theories, and hence they partly overlap and can be used side by side to complement each other (Schunk, 2012). As there is no established practice to study this type of technology-enhanced feedback, in addition to self-regulated learning, other theories, such as the theory of academic emotions (Pekrun, 2006; 2009) are also discussed in the forthcoming chapters.

3.1 Feedback and learning

There are two definitions to begin with. As Hattie and Timperley (2007) have pointed out, *feedback* is not feedback if it does not provide information about how to reduce the gap between the current and desired level in learning. Moreover, according to Schunk (2012, p. 4), what is universal in different definitions of

learning is that learning means *"an enduring change in behavior, or in the capacity to behave in a given fashion, which results from practice or other forms of experience"*. Although there is strong evidence that feedback has a powerful impact on learning (Hattie, 2012), the influence is not always as desired. In fact, feedback can be harmful (Fong et al., 2019; Kluger & DeNisi, 1996), and therefore understanding the mechanisms of feedback is crucial.

Several matters have to be considered, when designing the kind of feedback that would benefit learning. Whether the feedback is *positive* or *negative* is perhaps the most discussed factor, and will be dealt with first. There are amlarge number of studies evaluating the impact of positive or negative content of feedback on learning (for reviews, see Fong et al., 2019; Henderlong & Lepper, 2002; Hermsen et al., 2016; Kluger & DeNisi, 1996; Van Dijk & Kluger, 2010). Pleasant, encouraging or warmly formed constructive information is usually experienced as positive (Reddy at al., 2003; Rowe, 2010; Tennant et al., 2015). Often feedback perceived as positive contains information about what constitutes success (Van Dijk & Kluger, 2010). Praise is defined as positive evaluation about outcome, performance or behaviour (Henderlong & Lepper, 2002). Information about mistakes or errors (Van Dijk & Kluger, 2010) are usually considered negative. Unpleasant criticism or remarks are sometimes even experienced as unfair (Shenke, Ruzek, Lam, Karabenick & Eccles, 2018).

When the aim is to support appropriate behaviour, already Guthrie (1942) concluded that punishment as negative feedback did not reinforce appropriate behaviour as it did not provide a model of desired behaviour to replace the unwanted habits. He also warned that punishment might be perceived as provocative and even exciting (Guthrie, 1942), contrary to its intended meaning. In fact, praising desired behaviour would be a more useful method to manage classroom behaviour (Simonsen, Fairbancks, Briesch, Myers & Sugai, 2008). There are, however, findings that both positive and negative feedback can promote learning (Hattie & Timperley, 2007; Ryan & Deci, 2009, Van Dijk & Kluger, 2010), when the feedback is targeted to task performance or learning outcomes. Based on their experiments, Van Dijk and Kluger (2010) concluded that positive feedback is beneficial for tasks requiring creative thinking and problem solving, but positive feedback seemed to decrease performance in tasks requiring error detection and accuracy. Negative feedback seemed to function in the opposite way; it decreased creative thinking but increased accuracy (Van Dijk & Kluger, 2010). According to Ryan and Deci (2009; 2017), positive feedback may increase intrinsic motivation, whereas negative feedback decreases it. However, in their meta-analysis Fong and colleagues (2019) concluded that criterion-based, detailed criticism might also improve intrinsic motivation. Hattie and Timperley (2007), for their part, reminded that although negative feedback may enhance learning effort, it may be harmful to the inner volition to learn.

The second point of view in relation to feedback is to consider the intended target. The crucial point is whether the feedback is targeted at the learning process or the learner her/himself (Dweck & Master 2009; Hattie & Timperley 2007; Ryan & Deci, 2009). If the feedback is targeted at the learner, as a person, also praise, as positive feedback, can be detrimental to learning in the end (Dweck & Master, 2009). In contrast, corrective criticism, as negative feedback, can be useful if it is targeted clearly to the process (Hattie & Timperley, 2007). The harmfulness of person-targeted feedback is due to the hidden message it contains. According to Carol Dweck (Dweck, 2006; Dweck & Master, 2009), person-targeted feedback is connected to understanding one's abilities and skills as stable, as incapable of developing. Therefore, in order to support learning, feedback should always point out that by using effort and choosing enough challenging tasks, it is possible for everyone to develop (Dweck, 2006; Dweck & Master, 2009; Masters, 2013). Moreover, it is known that feedback, which is sometimes positive and at another time negative if it is given by a significant adult, may blur the self-image of a growing adolescent (Harter, 2012). Kluger and DeNisi (1996) claim that negative feedback is usually experienced as related to the self and therefore changes the locus of attention away from learning. Furthermore, there is strong evidence that feedback should never be normative, thus pupils should not be compared with each other (Pekrun et al., 2014; Shute, 2008).

Most of the teacher's feedback is about the task in hand, whether it is correct or incorrect, and thus supports only the surface level of learning (Hattie & Timperley, 2007). Attali and van der Kleij (2017) argue that instead of lower-order knowledge acquisition, such as memorising, in order to support high-order learning feedback should be more complex than just information whether the answer is correct or incorrect. Therefore, if the aim is to foster problem solving or the transfer of knowledge, feedback should be elaborative in nature (Attali & van der Kleij, 2017; Shute, 2008). To provide tools to elaborate learning, feedback should contain an explanation of a problem, or should provide hints how to keep progressing forward (Attali & van der Kleij, 2017; Hattie & Timperley, 2007; Shute, 2008). If the task level of information is provided together with person-targeted praise, such as "you're good at this!", feedback may ultimately prove to have a harmful effect on learning in the end. Instead, feedback in relation to individual progress may develop learners' regulation of the learning process by themselves in the end (Masters, 2013). Both Atjonen (2014) and Vehkakoski (2020) remind us that an open and deep dialogue between teacher and a pupil would probably provide keys so that feedback would develop the pupils' skills at self-evaluate learning.

3.1.1 The impact of feedback on motivation

Motivation in the school context is defined as: "a set of interrelated desires, goals, needs, values, and emotions that explain the initiation, direction, intensity, persistence, and quality of behaviour" (Wentzel & Miele, 2016, p.1). It is moderated by such factors as self-efficacy beliefs, causal attributions, beliefs about intelligence and autonomy (Wentzel & Miele, 2016). In motivation research, dimensions such as approach/avoidance of task or situation, mastery/performance goals, and intrinsic/extrinsic strives for learning have been distinguished (Wentzel & Miele, 2016).

According to Ryan's & Deci's self-determination theory, motivation, "to be moved to do something" (Ryan & Deci 2000b, p. 54), is usually separated in terms of intrinsic and extrinsic reasons for action, although there is no strict border between them. Instead, it is suggested that there are actually five stages of motivation rather than two (Ryan & Deci, 2017). In the school context, intrinsically motivated pupils are enthusiastic to absorb knowledge, as they are interested in understanding the topic at hand in itself. Extrinsically motivated pupils may pursue learning goals in order to be praised by teachers or peers, or earn rewards from parents, for instance. It is known that initially external motivation may change to internal motivation and vice versa. Moreover, usually with age, motivation shifts from intrinsic to extrinsic at school (Harter, 2012). However, supporting intrinsic motivation in order to gain deeper learning is mainly recommended in the literature (Fong et al., 2019).

Motivation can vary from one situation to another and can be supported by efficient feedback. Kluger and DeNisi (1996) have argued that negative feedback is often considered self-related, thus reducing motivation. According to Ryan and Deci (2009), positive feedback is more beneficial to develop motivation than negative feedback. Henderlong's and Lepper's (2002) literature review emphasised that praise, as positive evaluation, may increase intrinsic motivation but may also decrease it. They concluded that the key element in praise is whether it is perceived as sincere or not (Henderlong & Lepper, 2002). Encouraging rather than demanding praise was found to be beneficial for motivation, although they reminded us that autonomous learners should not seek external approval in the first place (Henderlong & Lepper, 2002). It is suggested that feedback which emphasises pupils trusting themselves could support intrinsic motivation (Hattie & Timperley, 2007). Furthermore, feedback underlining the need for effort to progress in learning is also known to support intrinsic motivation (Dweck & Master, 2009). Motivation can also be supported by informing pupils that feedback after a task will be forthcoming (Pekrun et al., 2014), indicating that pupils value feedback. A recent meta-analysis of Fong and colleagues (2019) showed that overall, positive feedback is mainly recommended in order to support intrinsic motivation, as it seems to develop the perceived competence. However, they found also that

compared to receiving no feedback at all, negative feedback was useful (Fong et al., 2019). Specifically, constructive criticisms or instructional corrective feedback, which was not perceived as a threat to autonomy were found to be beneficial for intrinsic motivation (Fong et al., 2019). In terms of feedback, Reeve and colleagues (2009) remind us that pressuring and autonomy-threatening language in the classroom decreases motivation.

Miele & Scholer (2016) emphasises the importance of self-regulating motivation. Based on the theories of metacognition, expectancy-value and self-determination have created a model of metamotivation (Miele & Scholer, 2016). They argue that motivation can be regulated through conscious reflection of motivational states (Miele & Scholer, 2016). Monitoring (self-assessment of motivational states) the value of the task at hand, or expected success or failure, may play a key role in becoming an independent learner (Miele & Scholer, 2016). Therefore, it should be studied whether metamotivational knowledge can be made visible by providing feedback. There is at least some evidence that by means of technology-enhanced feedback it is possible to support motivation (Gambari, Gbodi, Olakanmi, & Abalaka, 2016), and therefore motivation was also measured in this study. Associations between technology-enhanced feedback and motivation is reflected through literature emphasising the role of self-regulated, autonomous learning.

3.1.2 Technology-enhanced feedback in self-regulated learning

There is no single theory of self-regulated learning. In fact, in terms of self-regulated learning, there are at least six well-known authors, among which Zimmerman alone provides three models (Panadero, 2017). These frequently cited authors complement each other's work by emphasising different aspects of mechanisms supporting self-regulated learning. The Corno's model describes volition and working habits, Zimmerman's concentrates on the social cognitive view, Boekaerts emphasises emotions, Winne information processing, Pintrich motivation, and Efklides metacognition (Boekaerts, 2011; Corno, 2008; Efklides, 2011; Panadero, 2017; Zimmerman, 1989; 2000; 2002). What is common to these different models is that they all describe self-regulation in task-related situations. According to Boekaerts (2011), teachers can support pupils' self-regulatory skills by predictable routines in classroom. While technology-enhanced feedback studied in this dissertation can be received unexpectedly and is often detached from a specific task, further studies should be carried out on how this type of feedback influences pupils' self-regulation. In this section, connections between feedback and self-regulation are described according to Butler and Winne (1995). Emotional processes as a part of self-regulated learning are discussed in section 3.2 Feedback and academic well-being, according to Boekaerts' model (2011).

According to Zimmerman's definition (1989, p. 1), pupils "can be described as self-regulated to the degree that they are metacognitively, motivationally, and behaviorally active participants in their own learning process". In other words, pupils can self-regulate their learning if they are able to reflect on knowledge, set goals and adapt their behaviour autonomously. Winne and Perry (2000) define metacognition as the awareness of academic strengths and weaknesses as well as reflection on cognitive resources. Moreover, Zimmerman (1989) underlines that to be a self-regulatory learner, one should be able trust one's abilities and use learning strategies, such as seeking feedback efficiently. Self-regulated learning, despite referring to the self, is not completely an inner personal process. Instead, the surrounding learning environment also influences self-regulated learning (Zimmerman, 1989). Thus, one powerful factor influencing self-regulation is the feedback received or sought from external sources.

According to Butler and Winne (1995), internal feedback processes, such as the setting of goals, decision-making, monitoring of different learning strategies and self-assessment, are the most important skills for regulating learning activities (see Figure 1). They continue that self-regulated learners are skilful in seeking and taking advantage of external feedback by themselves (Butler & Winne, 1995). External feedback from a teacher (or from a computer) confirms or shows a discrepancy between the current and the desired outcome (Butler & Winne, 1995). While some pupils are interested in learning new knowledge and skills deeply and volitionally, there are others who may do tasks only superficially and as quickly as possible. Therefore, the appraisal of external feedback is always dependent on the learners' individual goals, beliefs about learning, expectations of outcomes (Butler & Winne, 1995), or experienced social pressure of peers or parents (Zimmerman, 2000). Moreover, feedback mediates future goals; learners may either raise or lower their goals in terms of the received information (Butler & Winne, 1995; Zimmerman, 2000). Most of the self-regulation processes are unconscious, thus leaving more capacity for cognitive processing (Boekaerts, 2011). Only if there is a problem needing attention during performance should one be able to reflect consciously in order to develop (Butler & Winne, 1995). If technology-enhanced feedback is repeatedly received, more detailed studies should be carried out to see whether it may interrupt cognitive functioning. Butler and Winne (1995) remark that if the cognitive demands of a task are too overwhelming for a pupil, then feedback should provide clear support for regulating the learning and performance.
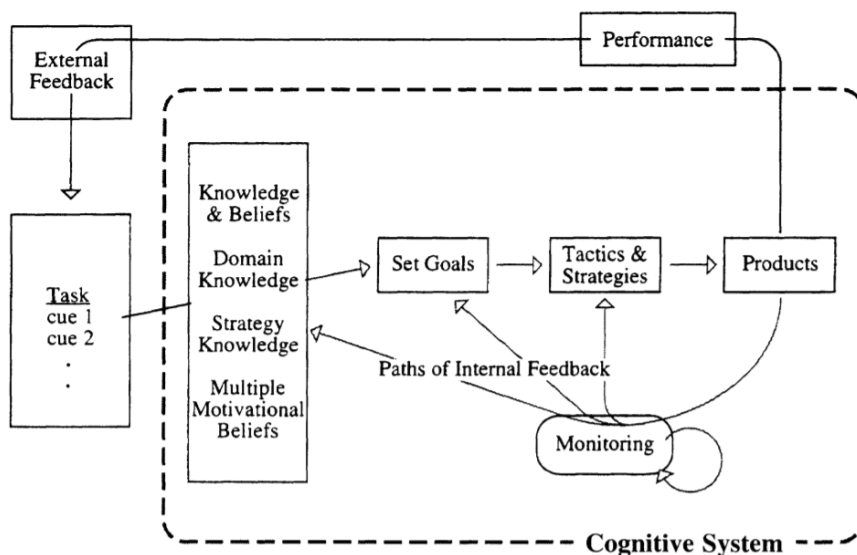
Figure 1. A model of self-regulated learning by Butler and Winne (1995). (Permission to use this figure has been given by Dr. Deborah Butler & Dr. Phil Winne. Permission has also been given by SAGE).

According to Hattie and Timperley (2007), feedback encouraging pupils to trust their effort and abilities can support self-regulation. Hattie and Timperley (2007) separate two dimensions in self-assessment skills in relation to self-regulation: self-appraisal and self-management, which are both essential in taking advantage of feedback. By *self-appraisal* they mean pupils' ability to evaluate knowledge and understanding of feedback in relation to goals. *Self-management* means readiness to regulate behaviour, such as planning, correcting mistakes, investment of effort or seeking of feedback (Hattie & Timperley, 2007).

During the last few years, there has been a growing interest in using learning analytics to research self-regulated learning (Noroozi et al., 2019; Noroozi, Järvelä & Kirschner, 2019; Winne, 2017). As technology allows feedback to be easily implemented, Winne (2017) reminds us that it should be studied whether the feedback via computer is efficient and whether it should be given during the learning event or afterwords as delayed. Persico and Steffens (2017) point out that learners may benefit from digital environments as they have more time to reflect on information. However, they continue that learning and the interpretation of information through technology requires self-regulated autonomy and control of choices, which not all pupils are prepared for (Persico & Steffens, 2017). Noroozi and colleagues (2019) concluded recently that it is possible to make pupils' invisible regulation of learning visible by learning analytics. Furthermore, Noroozi and colleagues (2019) have suggested that it would also be possible to support the development of self-regulated learning by providing individualised technology-enhanced feedback using learning analytics.

3.1.3 Matching individual differences and feedback

There are a variety of reasons why although a teacher may intend to link feedback to the learning process, for some reason a pupil understands the feedback as person-targeted criticism that is consequently harmful for learning. It is possible that a learner has cognitive difficulties, and therefore has faced challenges so often that receiving corrective feedback about mistakes feels almost like bullying. Hughes (2010) points out that pupils with learning difficulties may therefore reject the feedback as they are afraid of repeated failure. Vehkakoski (2020) noticed that pupils with special needs and negative self-perceptions about succeeding at school often reject teachers' effort to encourage them. Findings suggest that teachers' optimistic praise did not change pupils' negative self-perceptions (Vehkakoski, 2020). Van der Kleij (2019) reported that school achievements did not predict pupils' perceptions about teachers' feedback. However, it was noticed that school achivements predicted self-efficacy beliefs, adopted values and self-regulation skills, which all moderated perceptions of feedback (van der Kleij, 2019).

Kluger and DeNisi (1996) have concluded in the context of organisational psychology that depending on earlier learning experiences, pupils have four strategies for handing the feedback they receive. In the school context, their theory suggests that 1) when successful pupils receive corrective feedback they increase their efforts to reach the learning goal, 2) some pupils may change their goals after reflecting the feedback, 3) some pupils may even abandon their goals if they perceive the discrepancy between the current and the desired level of learning to be too devastating in terms of the feedback, and 4) some pupils with repeated negative information and failures may reject the feedback. Kluger and DeNisi continue that individual characteristics must be taken into account if the purpose of the feedback is to improve learning (Kluger & DeNisi, 1996). Moreover, Cutumisu (2019) concluded that the mindset adopted moderated how learners understand feedback; those who had adopted the idea that abilities are somewhat stable often perceived feedback to be person-targeted criticism, while those who thought that they could develop their abilities perceived corrective feedback as beneficial for them.

Pupils are also different based on their behaviour in the classroom, and it is known that some pupils may have problems in adjusting to the rules of the school. Oliver, Wehby and Reschly (2011) concluded in their review that teachers' classroom management practices are crucial in preventing harmful behaviour. Simonsen and colleagues (2008) detected by their meta-analysis that providing clear and detailed praise about desired behaviour can decrease inappropriate behaviour. They also gathered evidence that pupils with special needs may take advantage of feedback provided via computer (Simonsen et al., 2008). However, Corno (2008) warns that positive feedback, such as public praise about desired working habits

may result in a power hierarchy between pupils who are able to follow the norms and those who are not.

In recent years, the need for positive feedback as an encouragement to support pupils individually has been emphasised. There is evidence that based on personal characteristics, some pupils tend to experience negative information more strongly than others (Leikas & Lindeman, 2009), indicating that negative feedback is also perceived differently. Therefore, in some schools, interventions related to positive feedback to balance negative feedback have been carried out (Griffin, 2018). Pursianen (2018) has reported that the results of interventions are dependent on parents' commitment to providing positive feedback. Moore Partin, Robertson, Maggin, Oliver and Wehby (2010) suggest that teachers can support pupils with difficulties by providing praise whenever an opportunity occurs. However, Hotulainen (2003, p.5) claims that gifted children, who would also require attention and support to improve their learning strategies and develop their talents, are often left without positive feedback. Furthermore, there may be children who do not even recognise positive feedback although teachers may attempt to provide it (Pursiainen, 2018). Shenke, Ruzek, Lam, Karabenick and Eccles (2018) have shown that teachers deliver feedback differently for different pupils in a single classroom. It may be that teachers give feedback differently as they consider it is needed differently, nevertheless more studies are required to see whether pupils benefit from the feedback they are given.

3.2 **Feedback and academic well-being**

The Finnish legislation (§628/1998) emphasises pupils' overall well-being as follows: "Pupil welfare means action promoting and maintaining good learning, good mental and physical health and social well-being, and conditions conducive to these." Hence, pupils' well-being is also highlighted in the national core curriculum (FNAE, 2016).

Konu, Joronen and Lintunen (2014) define Finnish school well-being as pupils' perceptions of school conditions, social relationships and self-fulfilment. When feedback, learning and well-being are observed through the lenses of self-regulated learning, Boekaerts (2011) emphasises the role of emotions as a central factor. The idea in her model is that if a pupil considers a learning situation or task as for some reason threatening, such as feeling that the task is too hard, the negative emotion experienced leads the learner to the well-being pathway (Figure 2). She also points out that negative emotions may follow after receiving feedback, thus the appraisal of external feedback moderates whether a learner is able to concentrate on learning new skills and knowledge or whether the affective pathway interrupting learning is activated (Boekaerts, 2011).
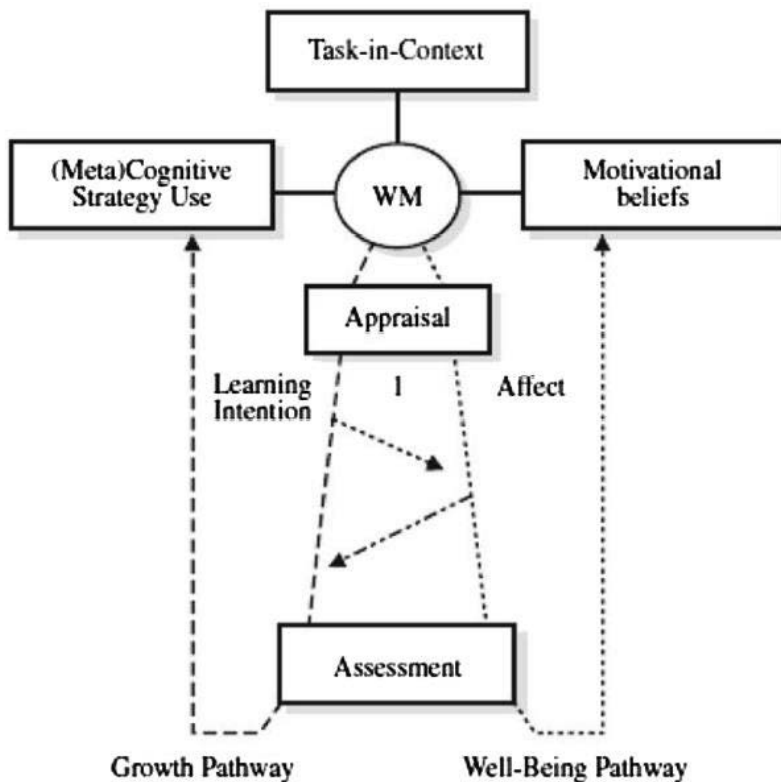
Figure 2. Boekaerts' (2011) dual processing self-regulation model. (Permission to use the figure has been given by Taylor & Francis Group.)

Korhonen, Linnanmäki and Aunio (2013) have shown that a perceived sense of competence is an important indicator of academic well-being. Therefore, academic well-being in relation to technology-enhanced feedback in this study is looked at from the perspectives of emotions, relationship with teachers and perceived competence.

3.2.1 Emotions moderating feedback

Experiencing emotions are a part of our unconscious, primitive reactions, and are known to have a crucial role in survival (Lang, 2010). The consensus among researchers is that emotions are inner experiences (Lang, 2010). Often anger, disgust, fear, happiness, sadness and surprise are defined as universal and basic emotions, which sometimes (but not always and not in all cultures) occur as facial expressions (Ekman, 1999). One of the duties of school is to raise pupils to control and regulate their emotions in a way that is appropriate in our society, as for some reason, showing "too much" emotion is considered inappropriate behaviour, alt-

hough there are cultural differences (Boekaerts, 2011). It is acceptable that children show and regulate their emotions differently compared to adults (Boekaerts, 2011).

Pekrun, Goetz, Titz and Perry (2002) have studied emotions in the school context in relation to self-regulated learning. Therefore, Pekrun's (2006) control-value theory of achievement emotions is used in this study in order to understand the relationship between feedback and emotions. In this theory, emotions are determined by control appraisals and value appraisals, namely whether a pupil is perceived to be able to control actions and what is the value of the achievement or outcome (Pekrun, 2009). In other words, in learning situations, pupils evaluate whether they are able to fulfil the requirements, and decide how much effort is needed and whether the goal is worth investing time and effort in. If the appraisal of the demand is negative, pupils may experience emotions such as frustration, anger, hopelessness or anxiety. When the appraisal of the situation is positive, then pleasant emotions such as joy, relief, contentment and pride will probably be experienced. Although emotions are usually considered either pleasant/positive or unpleasant/negative, according to Pekrun and colleagues (2002) they should not be labelled good or bad. For example, anxiety may increase effort and thus improve learning outcomes and joy may interrupt concentrating on the task at hand (Pekrun et al., 2002). In terms of external feedback, functioning may be likewise; if the appraisal of feedback is positive, even corrective criticism in the form of "negative" feedback may turn out to improve learning (Cutumisu, 2019). However, it must be remembered that usually negative feedback arouses negative emotions that interrupt learning (Butler & Winne, 1995; Boekaerts, 2011). Therefore, the development of self-regulation skills should be supported in order to cope with emotions when receiving feedback (Boekaerts, 2011; Eynde, De Corte & Verschaffel, 2007). However, coping with emotions is difficult even for adults, as Ryan and Henderson (2018) reported that university students who performed worse than they expected, often consider feedback more negatively than their peers do. This may indicate that they are unable to control their emotions while receiving feedback.

According to Carless (2006), university students experience both pleasant and unpleasant emotions when receiving feedback. The study of Harris, Brown and Harnett (2014) investigated the experiences of feedback of 9 to 15-year-old pupils in New Zealand. In the pupils' drawings about feedback, they found that 44% of of the drawings showed smilng faces, indicating positive emotions, and only 7% of the pictures indicated negative emotions when receiving feedback from a teacher. Zumbrunn and colleagues (2015) concluded that pupils' perceptions about their skills influenced how they reacted to feedback. Moreover, they reported that pupils experienced both pleasant and unpleasant emotions, such as pride or frustration (Zumbrunn et al., 2015). Rowe and colleagues (2014) found that pride and happiness occurred when feedback was related to students' goals

and success. They concluded that in addition to the aspect of feedback that promotes learning, teachers should always consider the fact that feedback also has a social dimension (Rowe et al., 2014). In other words, learners interpret feedback through their own history and interpersonal relationships. Recently, Loderer, Pekrun and Lester (2018) have shown in their meta-analysis that emotions also play a key role in learning in technology-based environments. Therefore, further studies should be carried out to investigate to what extent technology-enhanced feedback is associated with emotions.

3.2.2 Supporting competence and teacher-pupil relationships

Competence is defined as a need to experience effectiveness in terms of the learning environment (Elliot & Dweck, 2005; Wang & Peck, 2013). Furthermore, a sense of competence is closely related to motivation, as it is evident that one needs to perceive oneself as competent enough in order to have courage to show motivation. Therefore, both competence and motivation could be discussed under factors indicating learning and academic well-being. Experiences of the learning environment are largely related to interpersonal relationships. Recently, Griffin (2018) detected that negative criticism was harmful for both perceived competence and teacher-pupil relationships. Perceptions of teachers' unfairness are related to negative interaction (Gasser, Grütter, Buholzer, & Wettstein, 2018), and in contrast, a trustful teacher-pupil relationship enables handling even criticism (Skinner & Edge, 2002). There is strong evidence that teachers perceived emotional support to be a form of encouraging feedback and this had a positive impact on school adjustment and overall school achievements (Tennant et al., 2015).

The teacher-pupil relationship is shown to predict strongly the academic well-being of Finnish pupils (Lindfors, Minkkinen, Rimpelä, & Hotulainen, 2017). Unfortunately, according to PISA data, almost one-third of pupils perceived their relationship with teachers to be somewhat problematic (Linnakylä & Malin, 2008). As the technology-enhanced feedback observed in this study is delivered by a teacher and received by a pupil, it may be that it also represents power structures between parties (Atjonen, 2007; Cochran, Reinsvold, & Hess, 2017; Leary & Terry, 2012). Therefore, when the effect of technology-enhanced feedback on academic well-being is studied, it should include interpersonal dimensions.

3.3 Research questions

Digital devices and virtual activities produce quantifiable data. Platform developers often collect users' information and log data, but also school administrators could use data-driven evidence for decision-making (Wolf et al., 2014). At

school, pupils use a range of online platforms, raising their digital footprint. Traditionally, educational research data often consist of information gathered with a well-structured and designed questionnaire. This research study developed as an iterative process (Figure 3.) and began by collecting original and authentic digital feedback notes (N=211 003) from teachers (N=704) to pupils (N=7811) in order to first understand the special features of this type of feedback. When these data were driven from the platform, the content and a form of the data were a surprise. Therefore, in study I, the aim was to describe the data as clearly as possible in order to reach a reliable description of technology-enhanced feedback practices. In study II, the perspective on teachers' technology-enhanced feedback practices was broadened by looking at information on the individual support needs of pupils.

Based on evidence from studies I & II, two more sets of data, both quantitative and qualitative, were collected to create a versatile understanding of the phenomenon at hand. In study III, pupils' (N=2,031) self-reported technology-enhanced feedback was analysed in according with questionnaires related to learning and academic well-being. Finally, pupils (N=64) were interviewed about their perceptions in terms of the value of technology-enhanced feedback on pupils themselves (Study IV). By combining the evaluations of these three different data sets with four studies, it was possible to form an understanding of teachers' practices and pupils' perceptions about technology-enhanced feedback.
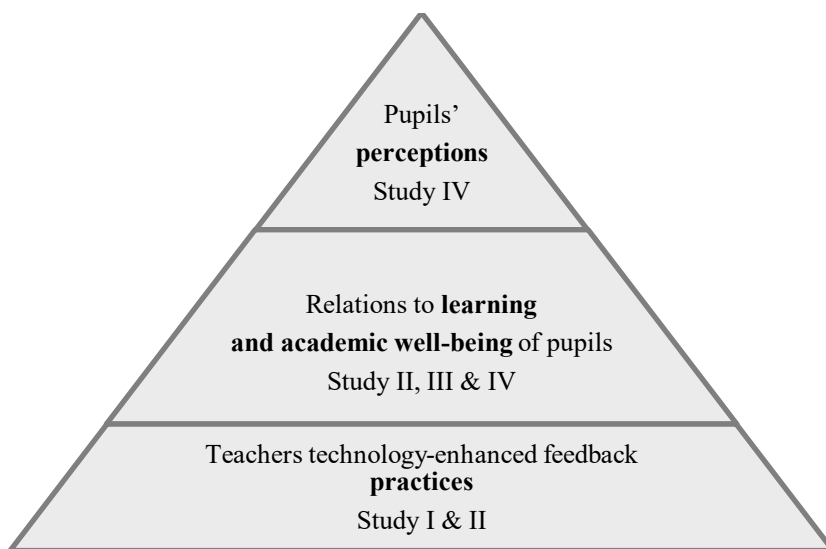
Figure 3. Research process showing the aims of the dissertation. The process began from the bottom by general evaluation of technology-enhanced feedback practices and then proceeded towards deeper perspectives.

The theoretical knowledge of feedback offered to support learning and academic well-being using the theories chosen in this study can be briefly summarised as follows. It is known that in order to be efficient, feedback should be targeted to the learning process itself rather than the behaviour or personal characteristics of the learner. If the aim of feedback is to improve behaviour, it should contain clear guidelines in terms of desired behaviour, as negative controlling feedback related to behaviour is experienced as punishments, often resulting in rejection. Moreover, it is known that feedback is related both to the cognitive and affective factors of learning although the result may sometimes be unwanted (Butler & Winne, 1995; Pekrun et al., 2014). Furthermore, there is evidence that the practices of teachers are not always in line with the suggestions of the literature (Black & Wiliam, 2018; Griffin, 2018; Shenke et al., 2018).

Experiencing strong emotions, such as joy or anxiety, during learning may interrupt cognitive processing. As feedback may arouse emotions, the timing of feedback should be carefully considered. Depending on individual characteristics, a pupil may react to the feedback differently (Boekaerts, 2011; Kluger & DeNisi, 1996). If a pupil has a tendency to experience negative information strongly, it may lower not only competence perceptions but well-being as well. Therefore, in this study, mixed methods were applied as they provided diverse opportunities to observe the relations of technology-enhanced feedback to learning and academic well-being of pupil as a whole. The research questions are:

RQ1: What kind of technology-enhanced feedback practices do teachers implement?
- In study I, teachers' practices, such as content and frequency of the feedback, were studied in terms of home-school collaboration
- In study II, it was studied whether pupils with special support needs received technology-enhanced feedback equally compared to pupils with no support needs.

RQ2: Is there a relationship between technology-enhanced feedback, learning and the academic well-being of pupils?
- In study II, it is assumed that all the pupils should be equally encouraged in terms of technology-enhanced feedback. Moreover, I argue that different treatment of pupils according to technology-enhanced feedback may have an impact on their perceived academic well-being.
- In study III, the relations between technology-enhanced feedback and learning and academic well-being were studied by measuring intrinsic and extrinsic motivation, school achievements, competence and relationship with teachers.

- In study IV, pupils' experienced emotions in connection with the technology-enhanced feedback they received were collected in order to draw conclusions about the affective factors of this type of feedback.

RQ3: How do pupils themselves perceive technology-enhanced feedback in terms of self-regulated learning and emotions?

- In study IV, qualitative data were collected to gain a deeper understanding of the nature of technology-enhanced feedback in terms of pupils' perceptions.

Finally, the aim of this summary is to draw conclusions about the four sub-studies. As the existing literature related to feedback shows that there is a gap in knowledge in terms of this type of technology-enhanced feedback, a conclusive model based on the findings of this study will be proposed.

4 Methods

When studying feedback, Brown and Harris (2018) point out that experimental settings do not necessarily describe the effect of feedback on learning in real classroom settings. They continue that although naturally occurring authentic data may produce fruitful evidence, the data collection and analyses can be challenging (Brown & Harris, 2018). This claim became clear in this study. For example, the authentic data were not normally distributed and therefore required various methods in order to gain reliable results (Kelly, 2017; Wolf et al., 2014). Moreover, studying the digital evidence driven directly from the online platform without consent of the participants, required careful consideration of the methodology and ethical issues before beginning the analyses. However, as Wolf and colleagues (2014) remind us, digital data-driven methods, such as learning analytics in educational research, are implemented to study practices in order to improve pupils' learning and not to judge teachers' efficiency.

4.1 Research methodology

By choosing the methodological framework, the researcher defines the philosophical way of understanding being in the world and of forming knowledge about it. Methodology provides guidelines for choosing methods, such as measures and analysis, for conducting research in practice. In this chapter, I describe the chosen philosophical frame to understand human ontology, in this case the sense of being a pupil or a teacher, and how epistemological beliefs, in other words knowledge about technology-enhanced feedback, are constructed (Houston, 2014). Epistemology in education is the study of the applicability of knowledge (Walker & Evers, 1997) and thus the aim of this study is to provide a theoretical understanding of the relations between technology-enhanced feedback, learning and well-being and the use of policy makers and practitioners.

When the use of technology is studied, one can expect that a modern framework of research philosophy is applied. Recent philosophers, of which Bruno Latour is one of the most well known, have co-authored the actor-network theory and studied the relationship between humans and machines. In their theory, the idea is that both humans and technology act as equal entities and subjects and hence they need to be studied side by side (Latour, 1996). However, in this study, the research philosophy represents a more traditional way of thinking. Technology is seen only in terms of equipment and the teacher who uses the technology to give feedback has the most active role. At the centre of all the actions and purposes of the use of technology should be the pupil who receives the feedback.

Originally, there have been two classical methodological approaches in education; the first one, *positivism,* has trusted only in empirical observations that measure the surrounding environment with quantifiable operations. The second one, *relativism* (or *constructivism)*, emphasises holistic, qualitative understanding of humans and their actions as social constructs (Husén, 1997; Raatikainen, 2004). Moreover, there have been at least two competing ways of understanding the surrounding reality: one is to think that reality is the same for all (realism) and the other point of view emphasises that there can be multiple realities, which can be understood through a holistic way of thinking (naturalism) (Guba & Lincoln, 1997).

Methodological approaches currently supported in educational research and which combine both quantitative and qualitative traditions include *critical theory* (Kellner, 2003; Lakomski, 1997), *realism* (different from the realism mentioned above) and *critical realism* (Luke, 2009). Critical theory is actually proposed by two independent movements, although they are quite alike (Klein, 2004; Raatikainen, 2004). Critical theory supports epistemological pluralism by admitting that understanding the complexity of educational problems benefits from both quantitative and qualitative methods, and therefore they can be used to complement each other (Kellner, 2003; Walker & Evers, 1997). Epistemological pluralism means that the theory of knowledge may vary between technical (quantitative tradition), practical (qualitative tradition) and emancipatory (critical theory) interests and these are all equally needed to construct an understanding of the phenomena at hand (Lakomski, 1997).

The concept of ontology in critical realism, unlike in positivism, accepts that there are real and even measurable entities that cannot be seen (Raatikainen, 2004; Virtanen, Haverinen & Leskinen, 2018). Thus, the conceptions of learning and well-being can be reliably studied. Besides, technology-enhanced feedback as a measurable item is a tool to understand the reality of teachers. Feedback related to behaviour is most likely provided to integrate pupils into society. When related to learning, traditionally, the purpose of feedback has been to produce a qualified workforce for the labour market. However, as modern school emphasises lifelong learning and the meaningful life of individuals, some schools and teachers have also started to use technology-enhanced feedback for the purposes of encouragement. Therefore, I refer to Heikkinen, Kiilakoski, Huttunen, Kaukko and Kemmis (2018), who see school and education ontologically as an initiation for the future. If the purpose of school is emancipatory, in other words to liberate humans by providing them with equal opportunities, the development of both cognitive skills and psychological strengths act as keys to the gate of freedom. An emancipatory perspective can also be justified with the fact that usually there is a power structure between the one who gives and the one who receives feedback (Atjonen, 2007; Cochran et al., 2017).

The aim of the current study, like most educational research, is to construct a theoretical and generalised understanding of the topic at hand. Realistic researchers, unlike strict relativists, consider themselves to be able to separate their personal beliefs from the phenomenon studied, and thus objectively construct new scientific knowledge (Raatikainen, 2004). Moreover, realistic researchers set hypotheses based on theory, but they are also open to correct or even reject them, as science is seen as an ongoing process in realism (Raatikainen, 2004). The quantitative methods used in sub-studies I, II and III represent realism by observing measurable entities and constructing a model from one reality, which however, may have hidden latent constructs (Virtanen et al., 2018), such as learning and academic well-being. Together with a qualitative understanding of multiple realities (sub-study IV) and accepting that the reality of technology-enhanced feedback is dependent on the observed subject and on variables, methodologically this study also relies on critical theory using mixed methods.

4.2 Ethical considerations

Ethics, the way we act as a human beings (Houston, 2014) and our position as an objective researcher is a primary consideration when scientific research is conducted. To separate everyday conceptions from scientific thinking, a researcher must continuously look at and question inconsistencies when forming knowledge (Hirsjärvi, 1985). This was particularly important in my case, since I had strong everyday conceptions about technology-enhanced feedback as I had been working as a teacher for several years. Furthermore, as a mother of two sons, I had received both pleasant and unpleasant technology-enhanced feedback notes from teachers during these years of parenting. Therefore, to ensure an objective evaluation of the research topic, I collected three sets of data, of which two are large quantitative data sets, as I considered that at least numbers are reliable. Moreover, data from qualitative interviews were collected, and analysed together with a colleague to avoid interpreting data from only one perspective. In all phases, the ethical principles of the Finnish National Board of Research Integrity were followed in order to protect the participants' rights.

As the aim of this thesis is partly to evaluate teachers' feedback practices, which may reveal hidden or even unconscious treatment of pupils, the second ethical issue concerns teachers themselves. The work of teachers is regulated by the Basic Education Act (§628/1998) and the national core curriculum (FNAE, 2016), which is an official steering document based on legislation. Besides national regulation, teachers should also follow international contracts, such as human and children's rights. When online platforms were adopted to schoolwork, there were no regulations or guidelines for teachers on how to implement technology-enhanced feedback. The gap in regulations naturally resulted in diverse practices. My aim was not to blame teachers for their practices, but rather to assess whether

there was a need to develop technology-enhanced feedback practices in order to support the learning and well-being of pupils. Wolf and colleagues (2014) also argue that authentic data should be gained directly from educational platforms in order to develop teachers' practices but not to judge them.

Besides the teachers' point of view, pupils' rights are the third ethical issue to consider, as they are in the most vulnerable position when research is conducted (Contract of Children`s rights). Below, I briefly describe three different data collected and observe the ethical issues related to data management and the reporting of results.

The first data were driven directly from the online platform with the permission of the administration of a Southern-Finnish municipality. The data consisted of 211,003 authentic and original technology-enhanced feedback notes from 704 teachers to 7,811 pupils from 38 different schools. Overall, the large size of the data made it possible to guarantee the anonymity of both teachers and pupils, as I did not report either the names of the municipality or the schools. However, agreement from teachers and pupils or their guardians was not collected as the municipality provided the data. Therefore, the data were reported even more carefully with the privacy and rights of the pupils and teachers in mind. We especially avoided using qualitative labels and names when pupils were classified into groups based on the received feedback from teachers. Technology-enhanced feedback creates a kind of digital footprint for both the teacher who records the feedback and a pupil at whom it is targeted. When I began the data collection, some teachers were surprised at the fact that all of the actions in the online platform are recorded and can be seen by administrators. The current study is also ethically important as it provides research evidence of the existence and content of this digital feedback record. Based on the data of this dissertation, it is apparent that some pupils have a large record consisting of their private information related to schoolwork. It should be clarified how this record is secured and who can have access to technology-enhanced feedback. During the research process, all data was handled anonymously and stored in external devices.

The second data were collected as part of the national Leaning to Learn Assessment at the Centre for Educational Assessment at the University of Helsinki. Altogether, 2,032 9th graders completed a questionnaire measuring values and beliefs related to learning in addition to learning to learn test items. The data were nationally representative and were collected based on cluster sampling, and therefore recognition of a single participant is impossible. To secure pupils' rights, I avoided labelling pupils based on their values and beliefs, as these should not have an effect on the quality of feedback they received from a teacher either.

For the third data, questionnaires and interviews were collected in three municipalities. Written and signed agreements from guardians were requested to allow pupils' participation in this study. Furthermore, it was of course voluntary for pupils to fill in the questionnaire (N=132) and sign up for interviews. All data

were collected anonymously and in each classroom there were pupils who did not want to participate in this data collection. We interviewed volunteered pupils (N=62) in groups consisting of two to six pupils in each. There were both pros and cons related to ethical issues in group interview situations: group discussions made the situation more comfortable for pupils, as they could talk and share ideas with peers instead of only an unfamiliar researcher. However, during the interviews some discussions occurred related to pupils' personal problems and emotions, which may have placed pupils in vulnerable positions in relation to their peers. In these situations, as a leader of the interview, I and my colleague led the discussion onto a more general level. The results and especially quotations were selected and reported carefully so that participants were impossible to recognise.

4.3 Context of the study

Since the 1970s, the purpose of Finnish basic education has been to provide equal opportunities for each child to succeed in life whatever their background, although lately, socio-economic status, geographical position and gender have played a growing role in determining pupils' achievements (Ahonen, 2014). In Finland, almost all pupils receive nine years of compulsory education at state schools, free of charge. Municipalities are in charge of 95% of schools providing basic education (OSF, 2019a). In addition, there are independent schools, such as schools administred by universities, where trainee teachers practise instruction. A minority of schools provide some specific purpose or alternative pedagogy, such as international, religious or Waldorf schools, and certain schools administrated by the state to provide education for pupils who have, for example, been taken into care. All schools are regulated by the national core curriculum, although teachers are relatively autonomous and are allowed to make pedagogical choices in implementing the guidelines (Ahonen, 2014; Tirri & Laine, 2017). This also concerns providing technology-enhanced feedback. In Finland, there are no standardised final exams for grading pupils, thus the assessment is based on teachers' evaluation of pupils' level of learning and behaviour (Atjonen, 2014). According to the guidelines, pupils are not compared to each other, but their achievements are compared with learning goals criteria defined in the national core curriculum (FNAE, 2016). However, there is evidence that pupils' individual and personal characteristics do have an effect on assessment, indicating that pupils are still to some extent compared to each other (Mullola, 2012).

In Finland, both Finnish and Swedish are official languages, in addition there are a number of other languages, such as English, Russian or Chinese, spoken among school-aged pupils. Only around 7% of the population of Finland have a foreign background and over half of these live in metropolitan areas in Southern Finland (OSF 2019b). Thus, the Finnish population is mainly quite homogeneous.

In Finland, the aim is to provide support for each pupil individually whenever there is a need. The earlier segregation of general and special education has turned into support provided by three tiers (Ahonen, 2014; Ahtiainen, 2017; Vainikainen, 2014). The three-tiered support aims to meet the support needs of pupils in a flexible fashion. Ideally, pupils may turn from one tier to another whenever there is need, although documentation of the provided support required is increasing the workload of teachers, and this means that the practices used in implementing support are becoming less flexible (Saloviita & Schaffus, 2016). In Tier 1 (or Tier 0, depending on the statistical treatment of the municipality), called *general support*, pupils are justified in receiving remedial special education after a period of absence for example (Vainikainen, 2014). In Tier 2, named *intensified support*, more effort is placed in supporting pupils' learning or behaviour. In Tier 3, *special support*, pupils require more individual attention, and support is also provided in segregated special education classrooms or schools. In all tiers, pupils may have individual support also from a special education teacher if needed. However, based on the idea of inclusive education, teaching is differentiated for each learner in pupils "home" teaching group, as far as it is possible. Thus, it is common that there are pupils who need support in Tier 1 as well as in Tier 3 in a single teaching group.

Since the renewed support model for special needs came into operation, the share of pupils receiving special support has decreased and the share of pupils receiving intensified support has increased (Lintuvuori, 2019). In 2017, varying from 14% to 23% in different regions, approximately 17.5% of pupils received intensified or special support (OSF, 2017). Boys were overrepresented in both groups. Of those receiving intensified support in Tier 2, 64% were boys, while of those receiving special support in Tier 3, 71% were boys (OSF, 2017).

4.4 Participants

Three sets of data were collected for this study to find evidence for each of the research questions. Data with participants are presented in Table 2.

The first data were collected only from a single middle-sized municipality from Southern Finland. With the permission of the administrators of this municipality, all authentic technology-enhanced feedback notes delivered during the school year 2014-2015 were driven from the platform for research purposes. In total, 704 teachers provided technology-enhanced feedback for pupils in grades 1 to 9. Thus, participants represented both primary and lower secondary schools. The share of pupils needing intensified or special support in this municipality was 23%, which was higher than the national average

The second data were a nationally representative clustered sample among ninth graders, collected from 28 municipalities. The data were collected in collaboration with The Centre of Educational Assessment of the University of Helsinki.

The third data were collected from three municipalities in Southern Finland among fifth and sixth graders. All municipalities participating in the data collection of the three data sets are presented in Appendix 1.

Table 2. Participants in the three data.

	Data I Study I & II	Data II Study III	Data III Study IV
Time	School year 2014-2015	May 2017	May 2018
N = pupils	7,811	2,031	132 / 64
Age of pupils	7-16	15-16	11-12
N = schools	38	31	3
Measures	211,003 authentic technology-enhanced feedback notes. Information of the three-tiered support needs.	Self-reported amount of received technology-enhanced feedback, learning to learn assessment and questionnaires	Questionnaire related to achievement emotions (N=132) and interviews (N=64)

4.5 Measures

In study I & II, data can be compared as a digital footprint recorded on an online platform. Before seeing the data, it was even impossible to guess what would be found and what kind of analysis could be implemented. The data consisted of technology-enhanced feedback notes given using ten predefined options; *active attendance, positive feedback, forgotten homework, forgotten supplies, undone duty, inappropriate behaviour, inappropriate use of language, exiting schoolyard, using mobile phone without permission* and *smoking*. Thus, teachers had an opportunity to provide feedback just by clicking the option needed at the time and as often as they chose to. Moreover, the information on gender, grade-level, hours of absence and the support needs of a pupil based on the three-tiered model were collected for the analyses of the second sub-study.

In study III, questions relating to received technology-enhanced feedback were constructed based on the results of study I & II. Thus, using a five-point scale (*1=never, 2=1-5 times in a school year, 3=around once a month, 4=around once a week, 5=several times a week*), pupils were asked to evaluate how often they had received feedback related to teacher praise, forgotten matters and behaviour problems. They were first asked whether they were familiar with technology-enhanced feedback and whether the platform was used in their school for feedback

purposes. Furthermore, they were requested to rate how important it was for them to receive technology-enhanced feedback. In addition to the questions related to technology-enhanced feedback, pupils answered questionnaires developed to study learning to learn according to the Finnish framework developed to study attitudes and values related to cognitive abilities (Hautamäki & Kupiainen, 2014; Niemivirta, 2004). Thus, there were items related to intrinsic and extrinsic motivation, perceived competence, and relationship with teachers measured with a 7-point Likert scale. Moreover, data also consisted of information on gender and school achievements, computed self-reported grades in mathematics, mother tongue, history and chemistry.

In study IV, pupils' experienced emotions related to the technology-enhanced feedback received were observed with a questionnaire using the taxonomy of achievement emotions created by Reinhard Pekrun (2006; 2009). A short questionnaire consisted on listed emotions, from which pupils were requested to circulate those they remembered to experience related to received technology-enhanced feedback (Appendix 3). Based on evidence from the first and second sub-studies, pupils were first told that it was common that there are pupils in each classroom who had received either a large amount of technology-enhanced feedback and pupils who did not have this type of feedback at all. This information was given in order to avoid arousing awkward thoughts about a "normal" amount of technology-enhanced feedback. Furthermore, altogether 16 group interviews of volunteered pupils were recorded by two researchers to collect qualitative data for the fourth sub-study. In interviews, semi-structured questions (Appendix 2) were used in order to produce comparable data. The questions were constructed based on literature related to feedback and the earlier research findings of studies I & II. In addition to the questions, pupils were encouraged to discuss technology-enhanced feedback as freely as possible.

4.6 Data analyses

No matter whether the data were quantitative or qualitative, analysis always began by reading through the information given to create an understanding of what was important to report. Descriptive statistics were required when the aim was to make generalizable judgements, and frequencies even with qualitative data reveal methods needed to conclude findings. The data analyses used in the four sub-studies are presented in Table 3, and then briefly introduced below.

Table 3. Overview of the original studies and methods.

	Title	Perspectives	Data and measures	Analyses
Study I	Technology-enhanced feedback for pupils and parents in Finnish basic education	Home-school collaboration	211,003 authentic technology-enhanced feedback notes from 704 teachers to 7,811 pupils during the school year 2014-2015.	T-tests & U-tests, MANOVA using SPSS as parametric methods and Mann-Whitney and Kruskal Wallis as non-parametric methods.
Study II	Is technology-enhanced feedback encouraging for all in Finnish basic education? A person-centered approach	Inclusive education, where the purpose is to provide support for all the pupils equally regardless of their individual differences.	In study II we included information about the individual support needs of a pupil based on the Finnish three-tiered support model.	Person-centred approach by using Latent profile analysis (LPA) with MPlus. MANOVA using SPSS.
Study III	Technology-enhanced feedback profiles and their associations with learning and academic indicators in basic education	Learning and academic well-being	Nationally representative sample (N=2,031) of ninth graders in spring 2017.	Latent profile analysis (LPA) using MPlus and MANOVA using SPSS.
Study IV	Pupils' perceptions about technology-enhanced feedback: Do emojis guide self-regulated learning?	Understanding of pupils' perceptions and perceived emotions in relation to learning and well-being	Interviews N=64 and questionnaires N=132 related to achievement emotions in three municipalities, in spring 2018.	Qualitative content analysis using Atlas.ti.

4.6.1 Nonparametric methods

In psychology and educational sciences phenomenon studied are rarely completely within a normal curve (Bono, Blanca, Arnau, & Gòmes-Benito, 2017). If we think, for example, of perceived competence, also measured in this study, it is understandable and common that humans tend to rate their senses and beliefs slightly positively. Therefore, the curve of self-rated scales are often either skewed or kurtosed, violating the normal assumption of most statistical analyses. Moreover, in real life, most phenomenon, such as anxiety or drug abuse, rarely deviate in a normal distribution (Bono et al, 2017). Technology-enhanced feedback in the real school world seemed to exist statistically as non-normal, resulting in a very high kurtosis and skewed data. In order to confirm the reliability of the findings, nonparametric methods are often used when normal assumptions do not meet the requirements (Field & Hole, 2003).

Mann-Whitney U-tests were used as a non-parametric method to compare the results of t-tests analysing differences between two groups, in this study gender. Kruskal-Wallis was used when observing the differences of more than two groups was needed. In correlational observations, the results of Person were compared to Spearman's rho indicating a non-normal connection.

4.6.2 Analyses of variance

Variance describes how much the actual values of the observed variable deviate from the mean on average. Variance analyses, such as univariate analysis of variance, ANOVA and multivariate MANOVA are both "classical" statistical methods developed in psychology starting from the late nineteenth century (Thompson, 2013). The difference between ANOVA and MANOVA is that while ANOVA studies the differences between observed means and variance of variables, the MANOVA does not test differences directly (Thompson, 2013). The analysis of MANOVA comes close to the regression, as it constructs weighted score-values according to the linear association of the variables observed (Thompson, 2013).

Univariate analysis of variance can be used when there is a single dependent variable to be explained by one or more independent variables. Assumptions for the use of ANOVA are that variables should be normally distributed, there are equal variances between treatments, and samples are independent (Field & Hole, 2003).

Multivariate analysis of variance, MANOVA, is implemented to study the relationships between and within one, two or more sets of variables, which should be normally distributed (Keeves, 1997). Multivariate analysis can define 1) whether there are similarities within one group of variables, 2) whether there are independent relationships between the observed sum of variables, or 3) whether there is an interaction between the sum of variables observed (Keeves, 1997). Dependent variables are measured with interval or ratio level data. The principle of

testing significance in multivariate tests is based on *the probability that some sample statistics are representative of a particular population parameter* (Keeves, 1997, p. 405).

Before conducting a MANOVA, at least four assumptions should be considered. 1) MANOVA is sensitive to outliers and therefore multivariate normality has to be observed (Bathke et al., 2018), for example, using a test for Mahalanobis distance. 2) A linear relationship between dependent variables across the level of independent variables is assumed. 3) The assumption of multivariate analysis is that variance in a covariance matrix is homogeneous (Keeves, 1997). 4) Multicollinearity of dependent variables should be avoided.

In both ANOVA and MANOVA, significant differences among the groups observed are detected using probability scores called p-values. However, as p-values represent only statistical difference, usually effect sizes need to be computed to make a judgement about the practical significance of the findings (Thompson, 2013). For instance, Cohen's d value, measuring effect size, gives information about the difference between mean values according to the units of standard deviation (Lenhard & Lenhard, 2016). The effect sizes of group comparisons are often interpreted by calculating Cohen's d in which values between .1 – .49 indicate a small effect, .5 - .79 indicate a medium effect, and higher than .80 indicate a large effect (Lenhard & Lenhard, 2016).

4.6.3 Person-centred analysis

The idea in most statistical analyses is to describe reality based on observed variables. Therefore, for example, the analysis of variance presented above can be called a variable-centred method. According to Mervielde & Asendorpf (2000), variable-centred approaches study the correlational structures of variables representing the meaningful characteristics of a population. Besides a variable-centred approach, a person-centred viewpoint can also be used to analyse data. Mervielde and Asendorpf (2000) illustrate that "person-centred approaches describe the structure of each member of a population by a configuration of multiple variables within the person" (p.37).

In this study, different patterns of receiving technology-enhanced feedback were studied using latent profile analysis (LPA) representing a person-centred approach. According to its name, LPA determines latent sub-groups as homogeneous profiles from the heterogeneous data (Oberski, 2016). The number of profiles is decided based on several fit indices, such as Bayesian criterion, the Vuong-Lo-Mendell-Rubin test and entropy values. Marsh, Lüdtke, Trautwein and Morin (2009), remind us that when there is a large sample size, LPA may produce profiles that differ according to the quantitative values, but this makes no difference with qualitative observation. Thus, the decision to use a profile solution has to be made with both observations.

4.6.4 Qualitative content analysis

Content analysis is only one way to interpret text data, ethnography or grounded theory being among the other possible approaches. Traditionally, there are three ways of conducting a qualitative content analysis, conventional, directed and summative (Assaroudi, Nabavi, Armat, Ebadi, & Vaismoradi, 2018; Hsieh & Shannon, 2005). The first two approaches differ according to the particular theory applied. In conventional analysis, data are interpreted and coded based on the phenomena that appear in the text. In directed analysis, codes for analysing the data are derived from theory. In summative content analysis, the researcher counts, for example, the frequencies of the appearance of specific words in a text. It is common for all forms of content analyses that they focus on the content and meanings of the text in its contextual framework (Hsieh & Shannon, 2005).

In the fourth sub-study of this dissertation, the approach of conventional content analysis was chosen in order to create an understanding of pupils' perception of technology-enhanced feedback. Usually conventional content analysis is recommended to describe a phenomenon that has not been dealt with by earlier studies (Hsieh & Shannon, 2005). To ensure a reliable analysis, two researchers blind-coded all the texts by letting themes arise from the data. After reading and coding the texts, the quotations were interpreted and classified in the light of the chosen theoretical framework (Assaroudi et al., 2018).

5 Overview of the original studies

Mixed methods were used to understand the current technology-enhanced feedback practices, the pupils' perceptions about these forms of feedback and to evaluate whether there is a connection between the given technology-enhanced feedback and pupils learning and perceived academic well-being. Below, each of the sub-studies with the main results are briefly introduced.

5.1 Study I

The purpose of the first study was to gain an overall understanding of technology-enhanced feedback, as there were no earlier studies about this topic in the Finnish context. In this study, technology-enhanced feedback notes were evaluated in the light of literature about home-school collaboration. The aim here was to understand the impact of feedback on pupils' learning and well-being through teacher-parent communication. The nature of this study was explorative and the following research questions were posed:

- What kind of technology-enhanced feedback as a form of lesson notes do teachers give to their pupils?
- Are there gender differences in the amount and quality of feedback?
- Are there gender differences in the amount and quality of feedback when feedback is analysed separately for different grade levels?

5.1.1 Procedure

To collect the data, all the authentic technology-enhanced feedback notes given in a Southern-Finnish municipality were drawn directly from a feedback platform. Altogether, 211,003 feedback notes had been sent from 704 teachers to 7,811 pupils in the 2014-2015 school year. Pupils in this sample were around 7 to 16 years old, studying in grades from one to nine in 38 state schools.

The data consisted of technology-enhanced feedback notes, which teachers could send to pupils and their parents by choosing from predefined feedback options. Including both positive and negative remarks, the original feedback options were: *active attendance, positive feedback, forgotten homework, forgotten supplies, undone duty, inappropriate behaviour, inappropriate use of language, exiting schoolyard, using mobilephone without permission* and *smoking.* In addition, information on the number of hours of absence was included in the data.

Feedback notes were observed by dividing pupils into three categories: 1st-2nd graders, 3rd-6th graders, and 7th-9th graders, based on the assessment guidelines of the national core curriculum for these units (FNAE, 2016). Before statistical analyses were carred out, feedback options were classified into three categories based

on the content and reliability analysis of the feedback notes. Descriptive statistics revealed a large variance between the minimum and maximum values of the technology-enhanced feedback given to pupils, and therefore the normality assumptions of the variables were violated. Both parametric and nonparametric methods were therefore used to confirm the findings. Gender differences were studied with t-tests and Mann-Whitney U-tests. Differences between grade-level, gender and feedback variables were tested using MANOVA.

5.1.2 Findings

Results from this first study showed that teachers provide feedback related to learning and behaviour during lessons based on three different contents; *teacher praise*, *forgotten matters* and *behaviour problems*. The results also showed that teachers were not consistent in their feedback to different pupils. In this data, some pupils received no feedback while other pupils received over 150 positive or negative remarks during a single school year.

Taking technology-enhanced feedback as a whole, 60 percent was teacher praise and it was sent to 70 percent of the pupils. Feedback related to forgotten matters, such as books or homework, covered 33 percent of the feedback notes, being sent to 76 percent of pupils. Feedback on behaviour problems was given most rarely, constituting only 7 percent of all the feedback notes and sent to 31.5 percent of pupils. 14 percent of pupils did not receive any technology-enhanced feedback.

Positive feedback in the form of teacher praise was given equally to both genders in grades 1-6, though girls received more praise in the upper grades. Boys received more negative or corrective feedback related to forgotten matters and behaviour problems at all grade levels. Most feedback was given to 7th-9th graders, which was understandable, as the oldest pupils study with several different subject teachers, who could all give feedback whenever they considered it would be needed. It is also likely, that when teachers teach younger pupils who do not have access to the online platform teachers probably prefer face-to-face rather than online feedback.

The Finnish Basic Education Act obligates teachers to keep parents and guardians updated about their child's performance and inform parents about problematic behaviour. However, it is obvious that constant negative messaging for some pupils jeopardises home-school collaboration, and consequently the well-being of pupils. Constant negative feedback may be even more detrimental for a pupil who reads the messages. Therefore, based on this first study, it was decided to concentrate on evaluating the connection between learning and academic well-being in more detail in my future studies. As a conclusion it was suggested that guidelines are needed to ensure the equal treatment of all the pupils in relation to technology-enhanced feedback.

5.2 **Study II**

In the second study, based on the finding from the first study, the aim was to extend the general understanding of technology-enhanced feedback practices. As the findings from the first study indicated an unequal distribution of technology-enhanced feedback notes to pupils, the aim was to detect whether pupils with different kinds of special needs were treated equally. Instead of analyses based on sample means, individual differences were observed with latent profile analyses in relation to the technology-enhanced feedback received from a teacher.

Inclusive education and the idea of one *school for all* is emphasised in Finnish school policy. Both research findings and the Finnish national core curriculum underline the need to encourage support for pupils with special needs to prevent future problems occurring (Hughes, 2010; FNAE, 2016). Pupils themselves also highlight the need for encouraging support (Ferguson, 2011; Rowe et al., 2014; Tennant et al., 2015), therefore the study focused theoretically on the role of emotional support in learning. The following research questions were studied:

- What kind of technology-enhanced feedback profiles can be identified in the Finnish context when an analysis is carried out separately for girls and boys?
- Is technology-enhanced feedback equally encouraging for all?
- Can feedback profiles be explained by membership in a certain teaching group?

5.2.1 Procedure

Data from the first study were supplemented with information on individual support need and the number of hours of absence of pupils (N=7,811). A three-tiered support model is implemented in Finland to provide support for learning whenever there is a need. Ideally, the support is provided flexibly within the pupils' own teaching group, although the support also require documentation. In Tier 1, called *general support*, pupils have an opportunity to receive remedial teaching and even part-time special education if needed. In Tier 2, named *intensified support*, more support is targeted to pupils to prevent problems in learning or behaviour. In Tier 3, *special support*, the idea is still to provide support in a pupil's home classroom, however, there are also segregated classrooms for special education. In the data of this study, 22.4% of pupils needed support in Tier 2 or Tier 3, which is above the average (16%) in Finland. Moreover, boys needed two times more support in Tier 2 or Tier 3 than girls, indicating the need for a gendered analysis.

The effects of school (N=38) and class (N=715) were first studied. Although the differences between schools and classes partly explained the variance, the descriptive statistics indicated clearly that there is also variation on the individual level within a single teaching group. Therefore, the latent profile analysis was computed for girls and boys separately. After identifying latent profiles, one-way

ANOVA and Mann-Whitney U-tests were run to study whether pupils in Tier 0/1 compared to pupils in Tier 2/3 are equally encouraged according to the technology-enhanced feedback received from a teacher. Finally, different profiles in a single teaching group were calculated in order to answer whether the membership in a profile could be explained by belonging in a certain teaching group.

5.2.2 Findings

Altogether six differently distributed latent profiles were identified for girls and five profiles for boys. According to identified profiles, girls and boys received technology-enhanced feedback with almost similar patterns. Over 70% of girls and boys belonged to the profiles, who mainly received praise but only less than 10 times a year. In addition, there were small groups of both genders receiving dozens of notes related to either praise, forgotten matters or behaviour problems. However, only boys were among those pupils (1.3%) who received a large amount of negative feedback. Boys belonging in this group also had the most absences. Deeper observation revealed that pupils with support needs in Tier2/3 were more likely to receive negative feedback compared to pupils who did not have a need for extra support in their schoolwork. In a single teaching group, on average three different profiles were found and even pupils belonging to the smallest profiles were distributed over a number of classrooms. These results mean that although feedback practices seemed to vary from one school to another, teachers provide feedback to pupils with different patterns inside of a single school classroom.

As encouraging feedback is highlighted both in research (Hughes, 2010; Tennant et al., 2015; Vehkakoski, 2020) and in the Finnish national core curriculum (FNAE, 2014), the identified profiles were named based on the level of provided teacher praise. To support the inclusive *school for all* perspective, it could be expected that teachers' practices should unite, not segregate pupils from one another. However, based on the observation of technology-enhanced feedback, it seems that at least feedback practices are not equally encouraging for all. Unfortunately, it seems that the treatment of pupils with support needs does not meet the idea of inclusive education. Furthermore, the results indicate that girls and boys are still treated somewhat differently at school. Although the effort to provide encouraging feedback for both genders was seen in the data, there were still a small group of boys who received cumulative negative feedback. As they also had the most absences, these pupils may be in danger of feeling that they are undesirable in the eyes of a teacher or even consider themselves to be outsiders at school. Based on these finding it was evident that more data should be collected in order to understand whether technology-enhanced feedback may have an impact on learning and academic well-being especially for those who receive repeated negative feedback.

Moreover, as some pupils received repeated praise, it should be studied whether it would be beneficial for them.

5.3 **Study III**

In the third sub-study, the aim was to study whether the findings from the first and second studies could be detected with a nationally representative sample. That is, whether participants would recognise the earlier determined technology-enhanced feedback categories, and whether there would be different or similar profiles according to received technology-enhanced feedback. Moreover, the aim was to gather evidence of the associations between received technology-enhanced feedback, and the learning and academic well-being of pupils. Motivation (intrinsic and extrinsic) and school achievements were studied to indicate learning. A perceived sense of competence and relationship with teachers were observed to evaluate academic well-being. Furthermore, pupils' perceptions of the importance of received feedback were collected. As the aim was to compare earlier findings from authentic data to nationally representative self-reported data, a latent profile analysis was first replicated. Secondly, relations between identified technology-enhanced feedback profiles and scales inciting learning and academic well-being were studied using MANOVA. The research questions were:

- Based on self-reported technology-enhanced feedback received from teachers, what kind of profiles can be identified?
- Are pupils belonging to the identified profiles different regarding their perceptions of learning and academic well-being?

5.3.1 Procedure

Data were collected in May 2017 together with the Centre for Educational Assessment of the University of Helsinki, as part of their nationally representative learning to learn assessment. Altogether, 28 municipalities participated and 2031 9th graders filled in the questionnaire.

In the questionnaire, pupils were asked to self-report whether they were familiar with the technology-enhanced feedback studied and if they had received (*1=never, 2=1-5 times in a school year, 3=around once a month, 4=around once a week, 5=several times a week)* feedback from a teacher via a smartphone related to teacher praise, forgotten matters or behaviour problems as detected in earlier sub-studies. Pupils also answered the questionnaire measuring their adopted attitudes and values related to learning and academic well-being using a scale from totally disagree = 1, to totally agree = 7.

Exploratory factor analysis was used to confirm the suitability of the questionnaire and the reliability of the scales. The school and class level effects were determined from the data by using maximum likelihood estimation. As most of the

variance seemed to exist on an individual level, a latent profile analysis was conducted. Finally, MANOVA between the identified profiles based on self-reported technology-enhanced feedback from teachers and scales measuring motivation, competence, relationship with teachers and school achievements was performed.

5.3.2 Findings

Observing the effects at the school and class level, revealed that the differences of technology-enhanced feedback practices providing teacher praise explained 15.2% of variance at the school level. This means that schools place different emphases on the importance of encouraging feedback, perhaps as a result of the renewed national core curriculum and public discussion, or because more attention has recently been paid to positive psychology in Finnish basic education.

Technology-enhanced feedback was given via online platform in each school participating in this study, although not all the pupils received it. The findings of this study confirmed the results from the first two studies; technology-enhanced feedback is given at least based on the contents of teacher praise, forgotten matters and behaviour problems as pupils recognised these categories and could evaluate how often they had been receiving these types of feedback. Furthermore, seven profiles were identified based on latent profile analysis. Compared to the second sub-study, the findings confirm that technology-enhanced feedback is given with different patterns to pupils. When the identified profiles are compared without information on the hours of absence, almost similar profiles were detected in this study with the nationally representative data as in a previous study with a sample only from one municipality (see Figure 4).

Comparing the identified profiles shows that in the self-reported data (study III) more pupils perceived receiving teacher praise than actually existed in the authentic data (Study II). Moreover, in the authentic data, there were profiles for both girls and boys that received a large amount of feedback related to forgotten matters. In pupils' self-reported data, these profiles were not found, although pupils in some profiles reported receiving a lot of feedback about forgotten matters. In both data sets there were profiles for pupils who did not receive any technology-enhanced feedback. It can be concluded that pupils receive technology-enhanced feedback with different patterns and this may have an effect on their appearance at school.

Regarding the associations between identified profiles and scales measuring motivation, school achievements, competence, relationship with teachers and the perceived importance of feedback showed that pupils who reported receiving mainly positive feedback evaluated their learning and academic well-being indicators the highest. As their school achievements were also the highest in the sample, it is possible that teachers praise pupils who are already motivated and well-adjusted. It was quite surprising that pupils who reported that they did not get

technology-enhanced feedback at all, evaluated all measured indicators of learning and academic well-being the lowest. This finding raises the question whether these pupils perceive themselves as being overlooked by the teachers, as the largest variation in reported values was seen especially in relationship with teachers. Based on sub-studies I and II, I would have conjectured that those who received repeated negative feedback would probably have suffered from it. However, this hypothesis was not confirmed. Hence, the final sub-study was designed in order to form a solid understanding of pupils' perceptions of technology-enhanced feedback.
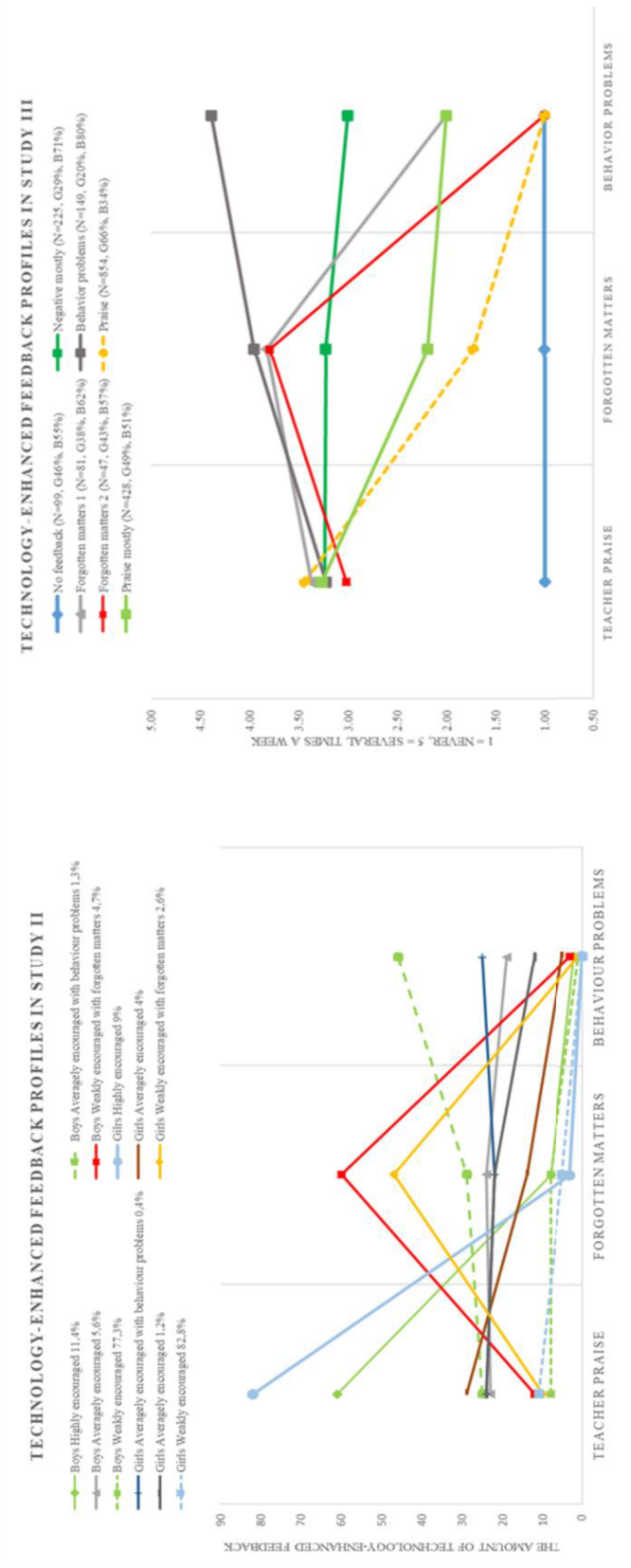
70

Figure 4. Comparison of the identified profiles according to received technology-enhanced feedback in studies II and III.

5.4 **Study IV**

Receiving feedback via smartphone has been a daily practice for at least a decade in Finland. However, pupils' thoughts about technology-enhanced feedback has not been researched. In this study the aim was to study pupils' perceptions and emotions related to technology-enhanced feedback, as sub-studies I, II and III clearly indicated that the current form of technology-enhanced feedback is recognised by pupils themselves and is associated with indicators of learning and academic well-being. The framework for self-regulated learning and the model of academic achievement emotions (Pekrun, 2006) were chosen as viewpoints to observe pupils' understanding of the impact of technology-enhanced feedback on learning.

5.4.1 Procedure

The results of the first sub-study showed that pupils from grades to 3 to 6 were those who received a lot of technology-enhanced feedback in terms of all categories, *teacher praise*, *forgotten matters* and *behaviour problems*. Often, pupils will have access to this online platform for the first time when they begin their 5th school year, and therefore it was decided that data collection would be targeted to 5th and 6th graders. Data were collected from three municipalities. To be able to participate in the study, informed consent signed by a parent had be returned. First, pupils (N=132) answered anonymously a short questionnaire related to their experience of achievement emotions (Appendix 3). Before the questionnaire, based on the evidence from earlier sub-studies, pupils were told that it is natural that pupils in Finland have technology-enhanced feedback in different patterns. This introduction was made as it was likely that there might be pupils who had never had a single feedback note amongst the participants. It was considered that without an introduction, the questionnaire would arouse awkward feelings. After filling out the form, the volunteered pupils (N=46) were recruited into the group interviews. Altogether, 16 interviews were collected, using semi-structured questions to secure the comparability of pupils' free discussions (Appendix 2). Questions for the interviews were constructed based on the literature and the findings from the earlier sub-studies of this thesis,

Although questionnaires provided quantitative data, these were analysed only qualitatively by observing the frequencies and percentages. In terms of interviews, to secure a reliable qualitative content analysis, all of the interviews were read through and analysed by two researchers independently. The identified thematic categories were then discussed and interpreted through theories

5.4.2 Findings

Pupils reported experiencing a variety of emotions related to the technology-enhanced feedback that they had received from teachers. Emotions ranged from pleasant to unpleasant; however, positive emotions like joy were most frequent. There were 24% of pupils recalled only positive emotions related to received technology-enhanced feedback and only one pupil reported solely negative emotions. Otherwise, pupils had experienced around 3.5 positive emotions and 1.6 negative emotions. In group interviews pupils discussed with each other that sometimes receiving technology-enhanced feedback aroused emotions like frustration. Pupils told that they felt frustrated if they were unhappy about their own actions during the school day, or if they thought that the teacher had acted unfairly. Moreover, according to pupils' discussions, frustration was also related to repeated and meaningless smiling emojis. These findings indicated that receiving technology-enhanced feedback might increase emotional disturbance, at least if these feedback notes were received during the school day.

In interviews, pupils' overall perceptions of technology-enhanced feedback were quite positive and they reported that they would like to receive feedback notes even more than they currently did. Pupils perceived technology-enhanced feedback as useful, stating that they monitored their level of learning and behaviour as a result of feedback notes. They thought that both positive and negative remarks were needed to regulate specifically their behaviour. In interviews, pupils described that behaviour and for instance active attendance during the lesson were important indicators of learning. It would seem that technology-enhanced feedback guided pupils to understand learning as something that could be assessed by observing external behaviour.

As received feedback had an effect on the future goals of the learner, it could be that technology-enhanced feedback related to external behaviour direct pupils to adopt appropriate behaviour as a goal. Instead of inner learning processes, pupils are guided to regulate their superficial level of behaviour. The results of this final study indicate that pupils may be skilful in self-regulating their learning, but teachers should target their feedback to support adopting more meaningful learning goals. The findings from all four sub-studies are summed up in the discussion below.

6 Discussion

Literature on feedback, including also technology-enhanced information still usually describes experiments or interventions where feedback is designed to improve learning outcomes, although the current learning paradigm emphasises the role of autonomous learners seeking feedback themselves in order to self-assess the learning process. Feedback has become an important part of education and teachers' work since the need of formative assessment to support learning processes has been addressed (Atjonen, 2014; Wiliam, 2014). The importance of encouraging feedback as a part of formative assessment is also highlighted in the current national core curriculum in Finland. All assessment should improve the self-monitoring skills of a pupil to grow towards independency (FNAE, 2016). However, Vehkakoski (2020) has noticed recently that encouraging feedback from teachers was still more controlling than autonomy supportive. As technology-enhanced feedback has been given to pupils in Finnish basic education since the early 2000s, the purpose of this study was to examine whether technology-enhanced feedback is formative and autonomy supportive in nature. In brief, does it support the learning and academic well-being of pupils. This is particularly important if the purpose of school is seen as emancipatory, providing all pupils with equal opportunities to develop both a cognitive and a psychological capacity to grow towards freedom (Heikkinen et al., 2018).

When attempts are made to describe the effect of teachers' feedback, it must be remembered that several factors other than just the feedback itself have an impact on both learning and academic well-being. According to the methodological approach of this study, multiple realities do exist (Cuba & Lincoln, 1997), thus there cannot be a single conclusion. For instance, pupils' individual characteristics and earlier learning experiences are likely to influence the way in which technology-enhanced feedback is interpreted and the kind of processes that feedback will trigger. Therefore, epistemological pluralism, that is a holistic combination of quantitative and qualitative knowledge, was needed to understand the phenomenon as clearly as possible (Kellner, 2003; Lakomski, 1997). At the same time, the fact that knowledge may not be complete and stable must be accepted.

The evidence of the four articles gathered by analysing three data with mixed methods and presented in this dissertation support the argument that technology-enhanced feedback is related to both the cognitive and affective factors of learning and academic well-being of pupils. It can be concluded that teachers' unequal technology-enhanced feedback practices are related to pupils' perceptions of such feedback. Strong associations between technology-enhanced feedback, motivation, perceived competence and relationship with teachers were found. The results of this study may partly represent teachers' understanding of the feedback as well;

teachers may feel pressure to provide feedback and they fulfil this requirement by clicking the predefined feedback options. Overall, technology-enhanced feedback given in Finnish basic education in its current form seems to be different from scientific definitions of feedback that underline the importance of supporting learning by providing information on how to progress towards desired goals (Hattie & Timperley, 2007; Shute, 2008). Next, each research question with the results will be discussed separately, and finally a model of technology-enhanced feedback is proposed.

6.1 Technology-enhanced feedback practices

The first research question was to observe what kind of technology-enhanced feedback practices do teachers have in the Finnish context where they have an opportunity to choose the content from predefined options. When teachers use an online platform, it is possible that they may not consider that the purpose of this feedback supports learning in itself, as the majority of technology-enhanced feedback was related to behaviour. However, based on public discussions and interviews of the fourth sub-study of this thesis related to the use of these technology-enhanced feedback notes, both parents and pupils in Finland widely understanding that such feedback is part of assessment. Therefore, technology-enhanced feedback practices are likely to deliver a hidden message about what should be learned and how pupils should behave in order to meet the criteria and approval of the teacher. As early as 1989 Sadler wrote that: "*To remove some of the responsibility for assessment from teachers and place it in the hands of students may be considered to have the potential for undermining the teacher's authority… Assessment is regarded as strictly the teachers' prerogative: it sets them apart from their students and to some extent from parents and the rest of society*" (p.141). In contrast to supporting pupils' self-regulated and autonomous learning, current technology-enhanced feedback practices represent perhaps a more behaviouristic paradigm of learning, where the teacher has the power to judge and decide the appropriate ways of learning and behaviour. The finding is alarming, as controlling feedback decreases motivation and overall well-being (Deci et al., 2001).

Evaluating technology-enhanced feedback practices by using three data sets shows that the practices of a single teacher may well vary. Teacher praise may be offered to some pupils, while others receive feedback about forgotten matters or behaviour problems. This may be partly due to legislation, which obligates teachers to inform parents about discipline problems. However, the majority of all technology-enhanced feedback was positive. In interviews, pupils confirmed that teachers have individual practices; there are teachers who deliver technology-enhanced praise repeatedly using smiling emojis, and others who send minor and irrelevant remarks. Although pupils did not always know why they had received

notes, overall they perceived technology-enhanced feedback to be useful. The result is in line with earlier findings showing that pupils do not always understand the received feedback, but still appreciate it when they receive it (van der Kleij, 2019).

Observing the feedback practices by quantitative data revealed that unfortunately, pupils with special needs were more likely to receive negative feedback compared to pupils who did not need extra support for their learning. This result raises the question whether all pupils are equally encouraged, as those needing support do not receive supportive feedback equally. According to Ahonen (2014), special support is provided so that a pupil can "be united not segregated from society". Furthermore, according to inclusive education, a school should offer possibilities for all the pupils to learn as the way they are. Mullola (2012) has shown that often teachers' perceptions about pupils' educability has an effect on the assessment of the pupil. The fact that teachers give more negative feedback to pupils who are in a more vulnerable position at school based on their special education status may support Mullola's conclusions. To offer inclusive education and a school truly for all the pupils equally, teachers should pay attention to their feedback practices. There is a danger that by technology-enhanced feedback teachers may give an unintended, hidden message not only to parents but also to the pupils themselves about who is accepted and who is not. In interviews, pupils perceived it to be unfair if one was not given feedback. If the purpose of school is initiation into future life, the teacher should act as an ideal example of respectful practices. Besides the evidence of unequal support for pupils with special needs, the results of this study also showed that boys are likely to receive more negative feedback than girls. Therefore, it is urges schools to develop technology-enhanced feedback practices that encourage all pupils equally. Only if this is done will technology-enhanced feedback be considerd useful for learning in the future.

Data sets for this study were collected at three time points. Although they cannot be united or compared statistically, some kind of slight change in feedback practices can be seen. The first data consisted of authentic feedback notes given in the 2014-2015 school year. The second data were collected in April 2017 and the last set a year after. During this time, the national core curriculum was renewed in 2016, but the pupils participating in the quantitative data collection still followed the old regulation in which encouraging feedback was not highlighted as much as it currently is. While in the first data there were only approximately 10 percent of girls and boys who belonged to profiles that received a lot of teacher praise as positive feedback, in the second data as much as 80 percent of girls and 55 percent of boys reported that they mainly received positive feedback. This result may indicate that teachers have started to pay attention to encouraging pupils by technology-enhanced feedback during the change in educational regulation. However, according to all three data collected, some pupils did not receive a single technology-enhanced feedback while others received dozens. This is alarming, as

recent meta-analysis has shown that it is actually more beneficial for intrinsic motivation to receive even negative feedback rather than no feedback at all (Fong et al., 2019). To avoid unequal practices, guidelines for technology-enhanced feedback should be created.

6.2 Relations to learning and academic well-being

There are two rather opposing answers to the second research question, namely whether technology-enhanced feedback given in terms of learning and behaviour during the lesson has a relation to learning and academic well-being of pupils. Firstly, according to the literature, feedback is not in fact feedback if it does not provide information about how the learner can work to reduce the gap between the current level of learning and the desired goal (Hattie & Timperley, 2007). Moreover, Shute (2008) reminds us that feedback has to support learning to be formative in nature. This study indicates that the most technology-enhanced feedback in the Finnish context is teacher praise and remarks about forgotten homework or desired behaviour. The level of information is usually in the form of restricted statements and it is likely that they rarely provide suggestions about how to improve learning or behaviour. Therefore, based on the results of this study, it can be questioned whether these notes can even be considered feedback as they do not seem to address the learning process itself. Furthermore, if this type of technology-enhanced feedback does not improve learning, it cannot then be formative. Hepplestone and colleagues (2011) have concluded that if automated statement banks are used they should refer to the actual work of a pupil to be effective. Thus, this type of technology-enhanced feedback should also contain more individualised information about how the pupil can progress. Since the Finnish national core curriculum states that above all, feedback should be provided to support learning, it should be considered whether current technology-enhanced feedback practices meet these requirements.

Secondly, and almost contrary to what has been said above, the results of this study showed strong relations between received technology-enhanced feedback and indicators of learning measured by pupils' self-reported perceived intrinsic and extrinsic motivation, school achievements and perceived competence. Based on these results, it seems that the more positive technology-enhanced feedback pupils receive, the higher their rated indicators of learning, although causality could not be shown. Interestingly, pupils who reported never receiving technology-enhanced feedback, evaluated especially their motivation lowest. This is particularly interesting in the light of Miele and Scholer (2016), who suggest that by supporting the development of metamotivational skills, motivation can be regulated. Thus, further studies should be implemented to see whether technology-enhanced feedback can be used to improve metamotivation, as self-monitoring of motivation. The results of this study are also in line with the meta-analysis of Fong

and colleagues (2019), who concluded that even negative feedback was more beneficial to motivation than no feedback at all.

In interviews, pupils reported that technology-enhanced feedback notes were important to them as they felt that they could improve their grades by improving their classroom behaviour. By paying attention to the notes, pupils felt that they had a better idea about how they were doing. Discussions with pupils suggested they were skilful at self-regulating their learning-related behaviour. However, the results indicate that goals for learning were still set by a teacher, and in order to regulate learning, pupils needed external guidance from a teacher. Henderlong and Lepper (2002) question whether autonomous learners actually need the approval of a teacher as a form of feedback. Atjonen (2014) suggests that open conversations between teachers and pupils could shed light on more meaningful feedback practices that would support autonomous learning.

Academic well-being was observed by measuring pupils' perceptions of teacher-pupil relationships and asking pupils to recall the emotions they experienced when receiving technology-enhanced feedback. A strong association between technology-enhanced feedback and the relationship with a teacher was detected in quantitative data and a variety of experienced emotions were discussed in the qualitative data. According to the result, those who perceived their relationship with a teacher to be trustful and functioning, reported receiving mainly positive feedback. The group of pupils reporting that they have never received technology-enhanced feedback gave the weakest evaluations to their relationship with a teacher. In interviews, pupils described that there are always some pupils in their classrooms who receive little attention from the teacher because they are perhaps kind and quiet, or that they are neither "good" nor "bad" enough to get attention. This indicates that interpersonal relationships mediate the associations between technology-enhanced feedback and the academic well-being of pupils.

A variety of emotions were reported to be experienced in terms of received technology-enhanced feedback. Pupils are not only different based on their learning interests and knowledge, but they are also different based on their individual characteristics (Leikas & Lindeman, 2009; Rawlings et al., 2018). There is evidence that negative information is perceived differently (Leikas & Lindeman, 2009), indicating that perhaps some pupils face more stress when they receive negative feedback than others. Overall, this study confirms earlier findings that feedback is related to emotional experiences, and such experiences may interrupt learning (Boekaerts, 2011; Butler & Winne, 1995; Pekrun, 2006; Shute, 2008). Although one third of experienced emotions were negative, fortunately the great majority of experienced emotions related to received technology-enhanced feedback were positive according to the data of this study.

6.3 **Pupils' perceptions of technology-enhanced feedback**

The third and final research question concerned pupils' perceptions of technology-enhanced feedback. Decades ago emphasis was placed on the need for feedback to reduce learners' dependency on the teacher and provide knowledge how to develop skills to self-regulate learning processes (Sadler, 1989). The results of this study can be looked at again from two opposing angles. First, technology-enhanced feedback seems to increase learners' dependency on the teacher as in the interviews pupils said that they would like to receive even more technology-enhanced feedback in order to know how they are doing. However, they also pointed out that especially smiling emojies, when given repeatedly, become boring. Secondly, pupils may well perceive encouraging technology-enhanced feedback to be useful to them as it may increase their self-belief as capable learners. Positive feedback from a teacher may also be experienced as social support and thus valuable for the learner (Tennant et al., 2015). The results of this study partly indicate that praise may be perceived as a teacher's sincere effort to encourage pupils in their studies, as a meta-analysis of teacher praise shows that encouraging feedback is beneficial for learning and motivation if it is perceived as sincere (Henderlong & Lepper, 2002). However, there is also strong evidence that praise may not be as effective in supporting autonomous learning (Deci et al., 2001; Henderlong & Lepper, 2002; Vehkakoski, 2020). Hattie and Timperley (2007) point out that feedback encouraging pupils to trust their effort and abilities may support the development of self-regulated learning. Hence, teachers should pay attention to whether the feedback they provide is controlling or autonomy supportive in nature.

Pupils' perceptions about technology-enhanced feedback were also studied quantitatively by requesting pupils to evaluate the importance of encouraging feedback in supporting their learning. Pupils who reported that they never received technology-enhanced feedback and pupils who received mainly negative remarks, gave the lowest evaluations to the importance of feedback. These pupils also gave the lowest evaluations to their relationship with teachers, which may indicate that rejecting the importance of encouraging feedback might be connected with troubles in interpersonal relationships. Earlier findings show that pupils' individual characteristics mediate perceptions about feedback (Hughes, 2010; van der Kleij, 2019; Kluger & DeNisi, 1996). Furthermore, in every school there seem to be pupils who face failure after failure, ending up rejecting even positive feedback (Pursiainen, 2018). Therefore, it is crucial to support all pupils as equally valuable individuals.

6.4 **Limitations**

There are of course limitations to consider in the four sub-studies presented in this thesis. First, it is true to say that cross-sectional data does not enable causality

assumptions, and therefore, longitudinal data would be needed to reliably confirm the findings of the relations between technology-enhanced feedback and the learning and well-being of pupils.

Secondly, as the data in the third study was collected in association with a learning to learn assessment, the instrument used was perhaps not the best one to measure learning and academic well-being. For instance, according to self-regulation literature (Butler & Winne, 1995; Zimmerman, 2000), feedback also influences the setting of goals and the perceived sense of control (Kluger & DeNisi, 1996). As these indicators were not studied in this research, they should be included when the impact of technology-enhanced feedback on learning and academic well-being is studied in the future.

Thirdly, as the topic is relatively context specific, universal claims cannot be drawn. Although there were three data sets collected in order to create an understanding of technology-enhanced feedback, it must be remembered that this type of feedback delivered by clicking the predefined options based on mainly behaviour during the lessons may be rather unique. Therefore, the results of this study may not be comparable to more traditional research studying task-related feedback. In the future, analysing teachers' freely written comments would provide more profound descriptions of teachers' feedback practices.

Technology-enhanced feedback given by using predefined feedback options represents only one dimension of feedback. For example, gestures and tone of voice are an important part of oral face-to-face feedback in the classroom and clearly have an effect on how one interprets the received information from a teacher via technology. Interpersonal relationships formed during the school day may reflect on the delivered technology-enhanced feedback. On one hand, analysing technology-enhanced feedback may offer only a limited perspective of feedback practices. On the other hand, technology-enhanced feedback practices may indicate face-to-face feedback practices that are often difficult to study otherwise. Nevertheless, the results of this study reveal meaningful insights when evaluating whether teachers' feedback practices follow the guidelines of the core curriculum and literature.

6.5 Proposing a model of technology-enhanced feedback

In their synthesis, Butler and Winne (1995) proposed a wish that feedback literature and knowledge of self-regulated learning could be merged in the future. There are several models about how teachers should implement feedback (Brookhart, 2013; Hattie & Timperley, 2007; Shute, 2007) and a model from Kluger and DeNisi (1996) describes how the individual differences of the receiver of the feedback should be taken into account to avoid interrupting the locus of attention during task performance. Moreover, there are promising studies related to technology-enhanced feedback and metacognition (Timmers et al., 2013) and a proposal that

encourages researchers to study metamotivational skills in order to support self-regulated autonomous learning (Miele & Scholer, 2016). Recently, van der Kleij (2019) published a model describing the factors that mediate pupils' perceptions about feedback. However, at least to my knowledge, there is no model that describes the cyclical and intertwined processes of learning and academic well-being in terms of technology-enhanced feedback specifically from the learner's point of view. Based on Boekaerts' model from 2011 (see page 43), and the evidence of the four sub-studies of this thesis, I propose a model of technology-enhanced feedback as a process (Figure 5).
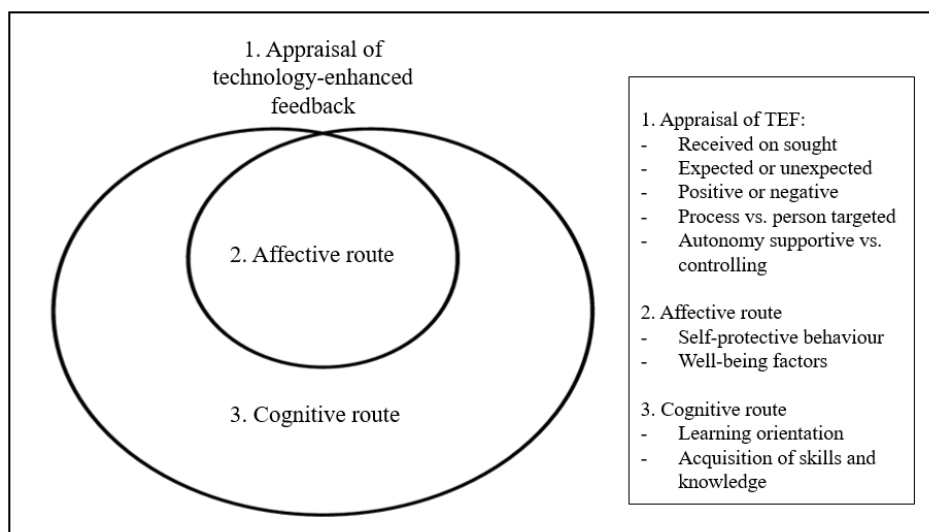
Figure 5. A model of technology-enhanced feedback as a process. (The image of the Limaçon of Pascal, invented in the 17th century, is used in the figure to depict cognitive and affective routes. Zdziarski and Palka (2011) define the limaçon as a horizontally positioned circle in a reflective cylindrical transformation. Thus, the image will serve as a metaphor for the way in which technology-enhanced feedback processes reflect the operations of the learner.)

The model is built on a definition of *feedback as a process* proposed by Boud and Molloy, 2013. Boud and Molloy (2013) understand feedback to be continuous interaction between teachers and students and therefore they describe it as a process. Based on the evidence of this study, technology-enhanced feedback process mean that pupils should be supported to actively seek and take advantage of technology-enhanced feedback in interaction with the learning environment or a teacher. In this model, technology-enhanced feedback is understood as reciprocal information processed via technology between a teacher and a learner, or feedback designed and automated based on learning analytics.

In the model, the process of taking advantage of technology-enhanced feedback begins with the appraisal phase. Overall, the model proposes that seeking or expecting technology-enhanced feedback and experiencing it as positive and process-targeted may benefit learning by activating cognitive routes. Cognitive routes

enable the learner to concentrate on learning new skills and knowledge without interruptions from affective factors, such as fear of failure or receiving negative feedback. In contrast, receiving unexpected technology-enhanced feedback may interrupt learning (Shute, 2008) and activate affective routes. Moreover, if technology-enhanced feedback is considered to be negative or person-targeted it will most likely produce self-protective behaviours (Boekaerts, 2011; Kluger & DeNisi, 1996), thus leading to affective routes. Narciss & Huth (2002) remind us that learners' willingness to receive feedback is one of the factors that determine the effect of feedback. Therefore, learners seeking feedback by themselves could be more beneficial (Boud & Molloy, 2013) to activate cognitive routes.

The Boekaerts' (2011) model develops the idea that by self-regulating the process, learners may shift from an affective well-being pathway back to a cognitive growth pathway if they no longer feel that the task at hand is threatening. In the proposed model, the affective and cognitive routes are also flexible based on the pupils' abilities to self-regulate technology-enhanced feedback. According to Persico & Steffens (2017), learning through technology may require more self-regulation skills than traditional environments. Furthermore, Eynde and colleagues (2007) highlight the importance of building up pupils' self-regulatory skills in order to cope with emotional experiences while receiving feedback. Therefore, self-regulation of both affective and cognitive learning skills should be developed and supported first before implementing technology-enhanced feedback. Atjonen (2014) have pointed out that teachers should spend some time discussing with their pupils about the intention of feedback in order to avoid misinterpretations. Vehkakoski (2020) points out that conversations between teachers and pupils may guide pupils to take advantage of feedback to develop their self-assessment skills. Noroozi and colleagues (2019) suggest that developing self-regulated skills is even possible in technology-based environments by bringing learners' unconscious practices under conscious reflection.

As the current paradigm in education emphasises supporting pupils' growth as autonomous and self-regulated learners, the learning processes should begin from the learners themselves in order to avoid the harmful effects of technology-enhanced feedback on learning. It is known that feedback and learning goals go hand in hand, creating a loop in which feedback is reflected according to learning goals, and reflecting the difference between the current and the desired level of learning will further have an effect on future goals (Butler & Winne, 1995). If learning goals are set by learners themselves rather than by teachers, they would probably be more willing to seek and take advantage of feedback as well.

Most cognitive processing is unconscious (Boekaerts, 2011; Butler & Winne, 1995; Miele & Scholer, 2016). Sometimes the adopted schemas or epistemological beliefs may be false or even harmful for learning. Therefore, further research should be carried out to see whether technology-enhanced feedback is a useful method to bring unconscious practices under conscious evaluation. For example,

some pupils may think that speed indicates talent, and therefore they may try to complete the task as quickly as possible. Being provided with feedback that encourages the use of more time and effort, pupils may show qualitative progress. Lim and colleagues (2019) already have encouraging empirical evidence that self-regulated learning may well be supported by technology-enhanced feedback.

Becoming skilful at regulating any cognitive or affective factor requires practice and conscious effort. Miele and Scholer (2016) suggest that even motivation could be flexibly regulated by exercising metamotivational skills. Therefore, taking advantage of technology-enhanced feedback as a process can be regarded as a skill that should be practised and learned (Dawson et al., 2018). To adopt this skill, pupils should learn to evaluate autonomously what their goals are, when they need to seek feedback in order to progress, and why feedback arouses emotions. Open and reciprocal conversation about these questions with a teacher, could serve as a fruitful starting point for learning. Further studies on whether it is possible or even preferred to replace conversations with teacher with technology are also needed. Dawson and colleagues (2018) have already suggested studying the opportunities provided by sophisticated technologies in feedback processes. If the next step in educational technology is the use of artificial intelligence, will greater attention be paid to supporting learner autonomy or will a similar power structure exist between the learner and technology as there often still is between teachers and learners. In any case, the proposed model will hopefully provide a useful tool for teachers and learners themselves to understand the factors that influence technology-enhanced feedback as a process.

6.6 Conclusion and future implications

School-aged children and adolescents spend approximately half their waking lives at school. After school, the day may continue with friends, often the same peers as in the classroom. In the evenings, there is homework to be done. Nowadays, the borderlines between school and free time are even more blurred by technology, enabling messaging between teachers, pupils and parents at any hour of the day. If it is usually considered that school is a place where outgoing pupils succeed and prosper, what happens when learning and feedback is remoted to digital environments. Is it possible that technology enables a learning environment that also suits quiet and shy pupils? It it still uncertain whether pupils reflect on information provided via technology differently than information received face-to-face. It is possible that technology in itself somehow mediates experience. When educational applications that provide technology-enhanced feedback from a teacher are located side by side with social media applications in a pupil's phone, it may be that a pupil understands teachers' feedback notes as an indicator of social acceptance similar to "likes" in social media and not as information intended to improve learning. Whether this is the case or not, more research is needed. Moreover,

technology-enhanced feedback may be perceived as attention, which every child and adolescent usually longs for. An unfulfilled need for attention may explain the results of this study, showing that pupils who did not receive either positive or negative feedback reported the weakest responses to their relationship with a teacher.

Using technology builds up a digital footprint for its users. When the first data for this study was drawn directly from the online platform, some teachers were surprised as they had not thought that it would be possible for the administrator of the municipality to have access to these technology-enhanced feedback notes. Besides the teachers' concern, we must also consider the privacy rights of children when we require the use of technology in education. It should be carefully considered what kind of digital data can be recorded, what the purpose of this data is, are the data secure enough, and who destroys the data when they are no longer needed. In terms of technology-enhanced feedback, school authorities should consider who can have access to these notes, how long will those notes be seen, and what the purpose of delivering feedback is. The worst scenario would be that a register indicating continuous negative remarks might stigmatise a pupil. Nevertheless, data-driven evidence may also be beneficial guidance for decision makers as well as teachers (Wolf et al., 2014) when it is collected anonymously. Authentic digital data can be used to detect practices that support learning perhaps even more efficiently than traditional paper-based questionnaires (Brown & Harris 2018).

Research on feedback has long traditions starting with organisational psychology and productivity and ending with positive psychology that emphasizes a flourishing life. In the educational sciences, feedback mainly related to task-specific situations has been studied for decades. Although there is evidence that feedback does not always improve learning (Wiliam, 2016) and may even be harmful (Kluger & DeNisi, 1996), nevertheless feedback is emphasised as an important part of formative assessment that can support the learning process of a pupil (Black & Wiliam, 2018; Shute, 2008). Technology-enhanced feedback, at least when it is elaborative in nature, has been shown to be beneficial for learning (van der Kleij et al., 2015). Thus, when studying feedback, it should be kept in mind that feedback may address a variety of goals and the effect of feedback depends on its purpose. In order to draw conclusions about the effect of technology-enhanced feedback, our first attention should be directed towards what it was intended to improve in the first place. For example, one approach might be to target feedback that supports engagement by providing encouraging praise, and another approach might target feedback that improves task outcomes by providing information that replaces incorrect results with correct answers. The results of this study have shown that technology-enhaced feedback has often been targeted at behaviour such as forgotten homework or constructive attendance during a lesson.

At the beginning of this thesis, I wrote that literature related to feedback can be summarised by two almost opposing perpectives: 1) the purpose of feedback is

to control behaviour by rewarding desired performance, and 2) feedback is provided to support the autonomous learning processes of a pupil. The results of this study reflect these viewpoints and teachers seem to use technology-enhanced feedback in conflicting ways. As a result of the opposing purposes of technology-enhanced feedback, it may be that pupils themselves may feel confused about adults' expectations concerning their learning and behaviour at school. In the interviews, pupils reported that they need technology-enhanced feedback to know how they are doing, indicating confusion relating to expectations. Therefore, the purpose of feedback should be made transparent for pupils. It should be clear whether pupils are merely meant to behave properly, or whether they are expected to grow as independent learners. If the purpose is the latter, the usefulnes of technology-enhanced feedback provided by clicking predefined options should be questioned. Instead of providing confirmation of desired actions, teachers should encourage pupils to trust themselves and only seek feedback when they wish it to continue their learning process. At the least the feedback platform should be updated to permit reciprocal interaction between teacher and pupil. Moreover, pupils seem to be skilful at reflecting on their learning in relation to the technology-enhanced feedback received from a teacher. The problem is that current feedback practices guide pupils to conceive of their role as learners as somewhat passive: they think that they are doing their best when they exhibit the appropriate behaviour and earn positive comments as a result. Thus, current technology-enhanced feedback practices seem to undermine the learning process of the more meaningful contents. Henderlong and Lepper (2002) concluded in their review that although a teacher's praise seems to be beneficial for motivation, intrinsically motivated pupils should not seek external approval, as they should already know how they are doing. Instead, pupils should be encouraged to trust themselves as able to monitor their own learning. Recently, Vehkakoski (2020) has concluded that teacher praise is often more controlling than autonomy-supportive. Therefore, technology-enhanced feedback should be developed to be more learner centred. As pupils are skilful and willing to learn, they should also be allowed to participate in and regulate the feedback process in digital environments themselves. Both Atjonen (2014) and Vehkakoski (2020) point out that reciprocal discussions between teacher and pupil could direct the feedback situations in a direction that would support pupils' self-regulated learning.

In order to give evidence-based recommendations about effective feedback practices for teachers, we as researchers should ask ourselves whether there is enough available evidence. What should we study in order to support the development of autonomous learners in line with the current learning paradigm? If the purpose is to improve self-regulated learning, we should perhaps study how technology-enhanced feedback might be developed to arouse pupils' awareness of the unconscious practices that influence the goals and choices they make. Therefore, the current study can be seen as a step towards studying technology-enhanced

feedback in more detail in the future. Persico and Steffens (2017) have already noticed that learning in technology-enhanced environments requires stronger self-regulation skills than learning in traditional classrooms. In digital environments, learners must use more autonomy to set goals and make choices, although not all pupils are ready for that. This study has shown that pupils require technology-enhanced feedback in order to know how they are doing at school, indicating that they need teachers' judgement and decisions. Therefore, it is essential to support pupils' development of self-regulation as it is evident that learning will inceasingly apply technology in the future.

When publishing the first sub-study of this dissertation, I cited Shayne (2008), who concluded that parents still prefer face-to-face discussions over technology-enhanced feedback. In the second sub-study, I cited Palts and Kalmus (2015), who wrote that parents perceived online platforms in home-school collaboration to be both useful and frustrating. During the publishing process of the third and fourth sub-studies, the circumstanies for teaching and learning dramatically changed because of the global health crises and no one could protest against using technology any longer. We can only guess how things are going to develop in the future, but still one thing is certain: technology-enhanced education and feedback has become an everyday practice, and therefore one needs to understand that this type of feedback is not merely meaningless clicking. Instead, it is clearly connected to the learning and academic well-being of pupils. With the three questions of this thesis in mind, the evidence collected to gain support for my main argument can be summarised as follows: 1) teachers' practices indicate that they may not consider technology-enhanced feedback to be a tool that improves the learning processes of a pupil, indicating that the kind of technology-enhanced feedback described in this study does not fulfil the requirements of formative assessment. Teachers seem to use it to control the behaviour of pupils by means of rewards or punishment. 2) Pupils perceive technology-enhanced feedback to be important to them in order to know how they are doing. This indicates that they may have understood that external regulation of behaviour is more important than concentrating on internal learning processes. 3) Technology-enhanced feedback seems to be related to learning and academic well-being, as it seems to direct pupils to target their attention at behaviour regulation rather than at the regulation of learning. This may further influence perceived well-being, as the need of autonomy is likely to remain unfulfilled. Moreover, pupils experience a range of both pleasant and unpleasant emotions in relation to technology-enhanced feedback, indicating that it is not meaningless for them. Therefore, in order to develop equally encouraging feedback practices to support autonomous self-regulated learning, it should be accepted that, intended or not, even quick notes from a teacher may have a powerful effect on the learning and academic well-being of pupils.

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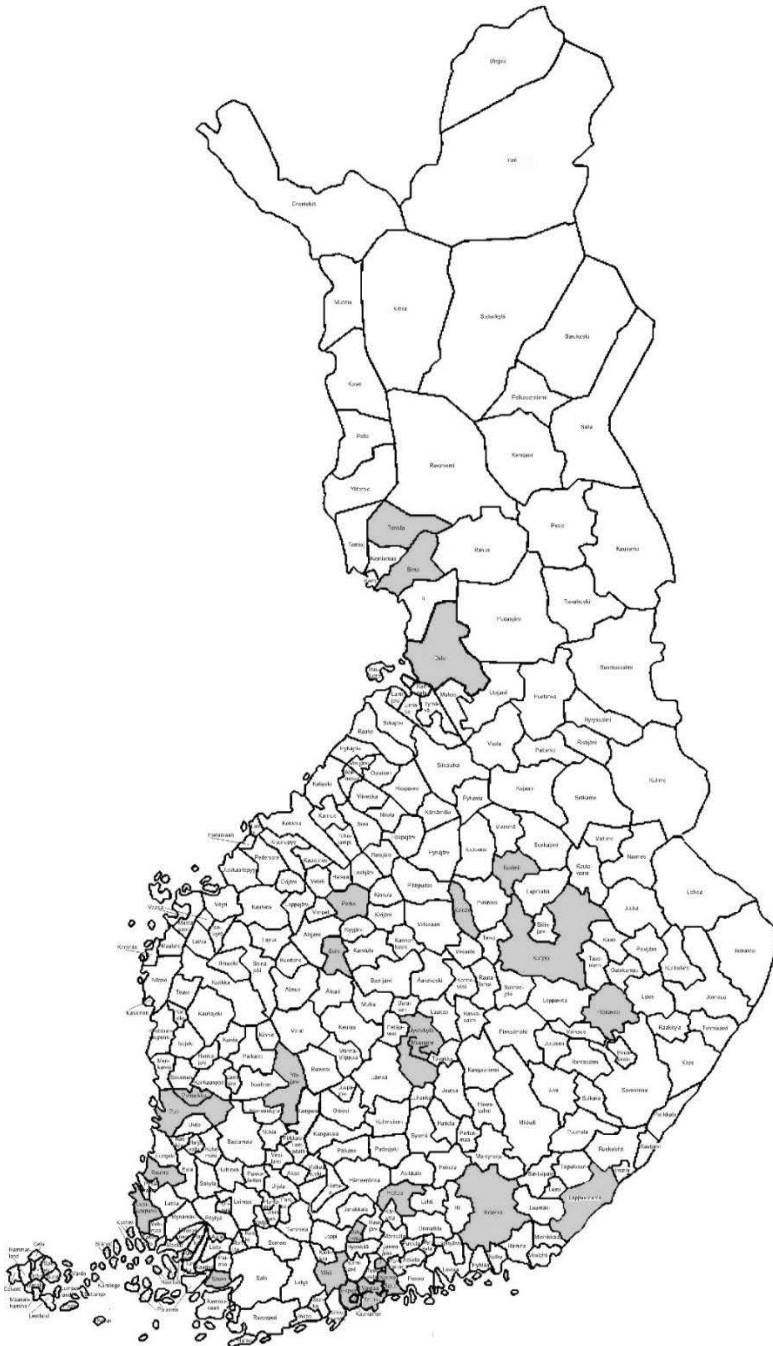
Appendix 1. Participating municipalities of the three data.

Appendix 2.

Procedure of collecting the interview data in study IV.
The instructions before beginning the interview were read aloud to pupils:
"*The interview will be recorded in order to ensure that your thoughts will be received correctly. Your names and your school name will be kept secret. Your first name is only recorded for the use of the researcher so that it is possible to separate your voices and thought from each other. Therefore, please tell me your first name or nickname for the recorder when we begin. I will ask questions, but I encourage you to freely discuss any issues which come to your mind related to technology-enhanced feedback.*"

Interview themes and questions:
1. How would you describe what technology-enhanced feedback means, if I did not know anything about them?
2. Do you have access to a feedback platform?
3. Do you know why technology-enhanced feedback is used?
4. Have you had conversations with teachers about why they give technology-enhanced feedback?
5. What kind of feedback practices do teachers have? Do teachers have the same practices?
6. How do you perceive technology-enhanced feedback? Is it the same as feedback received from teacher face-to-face in the classroom?
7. Do you discuss about the feedback notes with your parents?
8. What do you think about technology-enhanced feedback? What positive or negative thoughts do you have?
9. Do you think that technology-enhanced feedback is helpful for your learning?
10. What do you think about the number of feedback notes? Would you like to receive them less or more often?
11. It is common that in one classroom, there are pupils who do not receive any feedback notes and pupils who receive a lot of feedback. What do you think about this?
12. Do you have conversations with your peers about technology-enhanced feedback?
13. Earlier, you filled up a questionnaire related to experienced emotions. In some other schools, pupils had circled "frustration" and "joy" many times. What do you think is the reason for this?
14. If you could decide the options for providing technology-enhanced feedback, what kind of feedback would you then design? Give examples of feedback that you would like to have.
15. Are there other topics or important issues you would like to mention in terms of technology-enhanced feedback?

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Appendix 3. Procedure of collecting data evaluating the experienced emotions in study IV.

Before filling in the questionnaire, the instructions (text below) were read aloud to pupils.

"Here you see the examples of technology-enhanced feedback received by pupils *(the instructor points to the balloons pinned to the wall)*. It is usual to get feedback about active attendance, forgotten homework or disturbing behaviour. It is also common that there are pupils who do not get any feedback notes and thus you see an empty balloon.

Often teachers send feedback notes to parents, but in some schools, pupils also have access to the feedback platform and they can see the notes themselves.

Receiving technology-enhanced feedback may arouse emotions. Scientific research shows that joy or anger, for instance, may have an impact on learning and performance. Therefore, it is important to collect knowledge about what kind of emotions you have experienced related to technology-enhanced feedback. You can circle as many emotions as you remember to experienced according to technology-enhanced feedback notes."

Forgotten notebook!

You were active today, great!

Continuous chatting was disturbing.

QUESTIONNAIRE FORM

Please, fill up the questions below by circling the options that best describe your answer.

Gender: girl / boy / other

Do you have access to Wilma?   no / yes

Have you received feedback via Wilma?   no / yes

Circle what emotions you remember having experienced in relation to technology-enhanced feedback?

JOY	RELAXATION	ANGER	BOREDOM
HOPE	CONTENTMENT	FRUSTRATION	SADNESS
PRIDE	RELIEF	ANXIETY	DISAPPOINTMENT
GRATITUDE	ENJOYMENT	SHAME	HOPELESSNESS

(circle)

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