

Enhancing Computing Students' Learning Experience by Using ePortfolio for Formative Assessment

Hege Annette Olstad
Department of Computer Science
Norwegian University of Science and
Technology
Trondheim, Norway
hege.a.olstad@ntnu.no

Birgit Rognebakke Krogstie
Department of Computer Science
Norwegian University of Science and
Technology
Trondheim, Norway
birgit.r.krogstie@ntnu.no

Xiaomeng Su
Department of Computer Science
Norwegian University of Science and
Technology
Trondheim, Norway
xiaomeng.su@ntnu.no

Abstract— This Innovative Practice Full Paper presents how formative assessment using ePortfolio can enhance computing students' learning experiences and what influences the students' preference regarding formative assessment method. The international research literature reveals that ePortfolios primarily are used in study areas such as teacher education, creative disciplines, communication, and medicine. This study contributes to ePortfolio research within the discipline of computing education and introduces computing students to the ePortfolio integrated into the LMS Blackboard. The students are used to courses and associated assignments organized in folders in the LMS, but they have no experience with the integrated ePortfolio. We derive insight from thematic analysis of 67 summative reflections written by the students at the end of a course in Collaboration Technology and observation of the students' ePortfolios throughout the course. Findings in this study reveal two aspects of formative assessment with the ePortfolio that contributed to enhancing computing students' learning experiences. First, considering the ePortfolio as a process, the students gained professional identity, self-assessment skills, and transferable metacognition skills. Second, seen as a product, the ePortfolio provided the students with a comprehensive overview of achievements across topics and assignments in the course. The students perceived the two aspects as so essential that if they could choose between the ePortfolio and the traditional learning management system (LMS) folder assessment method, they would have preferred the formative assessment with the ePortfolio even though the ePortfolio increases their workload.

Keywords—computing education, ePortfolio, formative assessment, computing students' experiences, self-assessment

I. INTRODUCTION

Higher education learning environments tend to rely heavily on summative assessment at the end of a semester or academic year [1, 2]. Summative assessment makes students focus mostly on aspects such as the final exam, the grade, and the perfect research paper, while the steps in the learning process often become invisible [3]. When these steps become invisible, it can be challenging for students to recognize evidence of employability [4, 5].

The ePortfolio (electronic portfolio) has been suggested in the literature as a valuable instrument to help make the previously unseen layers of learning and achievements visible to students [6, 7, 8, 9]. ePortfolios are digital containers capable of storing students' examples of work, so-called artifacts, both visual and auditory content, including text, images, video, and sound [10]. As ePortfolios are easy

to share with peers, teachers, and others and let them provide feedback through a single electronic container, the ePortfolio has significant communication advantages [10]. However, the ePortfolio is not just a shareable container of student assignments. It also includes on what the artifacts represent and evidence for lifelong learning and skills in an academic and professional context [11]. As the students need to judge their work through reflections, the ePortfolio facilitates self-assessment [9]. The ePortfolio has also proven to make students able to articulate professional identity [12] and heighten students' levels of metacognition in relation to connections to learning and connections to career or personal goals [13, p. 6]. As the ePortfolio is a digital tool suitable for both campus-/classroom courses and online courses, it is also a tool that may be very relevant in the future when higher education must offer study programs and courses that are much more flexible than they are today to meet the diversity of the student population [14].

Today, ePortfolios are embedded within several LMSs as they provide a holistic approach to recording achievements and provide formative assessment in line with professional standards [15]. Although universities in Norway use LMSs with an integrated ePortfolio, it is challenging to get a complete overview of the usage. In Norway, the term ePortfolio or electronic portfolio is used in a broader sense than internationally. The term has also been used inconsistently in Norwegian context. For example, the European Institute for E-Learning (EIfEL) indicates that Dysthe and Engelsen use ePortfolio in teacher education [16, p. 15]. Dysthe and Engelsen do not use the term ePortfolio but 'digital portfolio' and 'digital folders' [17]. Furthermore, Hallam et al. point out that Norway has an ePortfolio vision, but the government ICT policy does not mention ePortfolio [18]. Much of the Norwegian literature refers to 'digital portfolios' or 'digital folders' in an educational context and according to Skyttermoen [19] with a focus on the use of folders in learning processes and assessment of learning. The ePortfolio is more than that because it is also a tool towards working life. However, the ePortfolio and work context has received modest attention in Norway [19].

There are several examples of how higher education courses are organized and conducted using digital portfolios or folders in the Norwegian educational context. Especially, such approaches have been subject to research from the perspective of teachers and educational intentions [20, 21, 22]. Typically, each course is organized in a digital folder

where course material is structured in a hierarchy of subfolders. With the help of teachers' feedback given in the various sub-folders, students can make improvements and then submit the assignments, which are subject to grading. Although students in these cases are key participants in formative assessment, student perspectives on such practices are relatively under-researched [23]. The international research literature on ePortfolios is dominated by studies on the use of ePortfolios in teacher education, creative disciplines, communication, and medicine [24], and there is a lack of studies on ePortfolio in Computing education.

The UN points out several competencies achieved through computing education as essential for realizing sustainable development [25, p. 118]. As such, Computing education is of high importance and relevance for several of the benefits illustrated by ePortfolio usage elsewhere, and it will thus be worthwhile to study ePortfolio in the computing education context. This study contributes to ePortfolio research within the discipline of Computing education. In this study, we introduce students from two different bachelor programs in the area of computing to the ePortfolio integrated into the LMS Blackboard. The students are already used to courses organized in folders in Blackboard, but they have no experience with the integrated ePortfolio. Based on prior knowledge about the ePortfolio when it comes to self-assessment, professional identity, and metacognition skills, this study explores the following two research questions (RQ):

- (RQ1) How can formative assessment using ePortfolio enhance computing students' learning experiences?
- (RQ2) What influences the students' preference regarding formative assessment method?

By increasing our knowledge and understanding of how formative assessment using ePortfolio can enhance computing students' learning experiences, we can help instructors make more informed decisions regarding course design and assessment.

II. BACKGROUND AND RELATED WORK

Assessment can serve many different purposes. While assessment methods such as diagnostic assessments are used before and sometimes after a course and summative assessment happens at the end of a course or a program, formative assessment facilitates students' needs during learning processes without grading. Through formative assessment, teachers monitor students' progress and provide feedback during tasks or activities [26, 27].

ePortfolios used for formative assessment have been shown to improve students' learning [28, 29] and have been pointed out as a tool for formative feedback as they facilitate peer and tutor feedback [30].

A primary part of formative assessment is feedback [31, 32, 33], which is seen as one of the most vital factors influencing learning [26, 34]. The role of formative feedback is to help students see what they know and what they can do and plan strategies for improvement [32, 35, 36]. Formative feedback is thus essential in a learning process, but formative feedback can also facilitate the development of self-assessment skills [37]. Through self-assessment, students judge their work to improve performance and identify discrepancies between current and desired performance. Self-

assessment thus occurs when students assess their performance. Through feedback, teachers can help students identify standards/criteria that apply to their work and strengthen students' ability to evaluate their work against expected goals [38].

Self-assessment is also a topic that often occurs in relation to ePortfolios, and especially related to reflection on artifacts and what they represent [11]. There is a consensus that the ePortfolio is both a product and a process as the development of an ePortfolio consists of both several activities and finished results [39]. Reflection is one of the activities and is fundamental to the development of an ePortfolio [6, 7, 9, 10]. However, Slepcevic-Zach and Stock [40] find in a study among students in a master's Program for Business Education and Development that reflection represents a great challenge for students [40]. To meet this challenge among students in Health Sciences and Biosystems Engineering programs, Ring et al. [9] developed a reflection model, the "What? So what? Now what?" with guiding questions intended to make the students think about what they have done, what they learned and what they are capable of because of what they have learned [9]. Such guidance questions can also facilitate self-assessment because the students need to judge their work [38], which can further facilitate metacognitive skills that help students recognize their strengths and need for improvement [41].

ePortfolios can support students' development of metacognition skills as the ePortfolio provides the student with a space to develop awareness learning and thinking processes as well as an ability to monitor, assess, control, and change those processes [42]. Such skills are generally referred to as metacognition [43, 44]: thinking about one's own thinking or the ability to plan, monitor, and evaluate one's own learning processes [45]. A study by Bowman et al. [13] revealed that students who developed ePortfolios had heightened levels of "metacognition in relation to connections to learning and connections to career or personal goals" (p. 6) compared to students who wrote paper-based portfolios. In the study by Bowman et al. all students were prompted to reflect on skills gained from the first year of a study program [13]. According to Harman [43], reflections can encourage metacognition, which is often recognized by both students and teachers when students are required to explain what they have done, how they did it, and why it was important [43]. For self-assessment the ePortfolio can be an essential facilitating factor, which can further lead to the development of metacognition skills.

Furthermore, self-assessment is also a crucial factor in professional development [46]. Tan et al. [47], define professional identity as "the self that has been developed with the commitment to perform competently and legitimately in the context of the profession, and its development can continue over the course of the individuals' careers" [p. 1505]. Guder [48] argues that professional development is a process that builds on the experiences of the professional through assessment and reflection learning [48]. Such an approach is in line with what Ring et al., found: reflection helped the students develop professional identity [9]. In turn, professional identity can also enhance students' motivation to learn [49]. Still one single learning experience or a course is just a piece of professional identity but is nonetheless

essential for student development of a holistic professional identity [50].

III. METHODOLOGY

A. Research case

The research was carried out at a large university in Norway. Two bachelor study programs were involved in this study: one campus-based and one web-based study program. Both bachelor programs offer courses that combine Business and Computer Science knowledge. Two undergraduate courses in Collaboration Technology, each belonging to one of the aforementioned bachelor study programs, were the venues for our data collection in this study. We denote them as Course C and Course W, respectively.

Both courses C and W have a 4-week module on CSCW (Computer Supported Cooperative Work) and digitalization, followed by an 8-week module on user-centered design (UCD). The courses have a practical orientation, with project-related assignments playing an essential part towards the intended learning outcomes. The intended learning outcomes, both at the study program level and at the individual course level, were developed at the university, as a result of the implementation of the European Framework for Lifelong Learning (EQF), [51].

There are altogether five mandatory assignments: one small introductory assignment (including writing a team collaboration contract), one CSCW assignment and three assignments related to UCD. The students work in teams of 3-4 on the assignments, which are handed in and approved for the group as a whole. Fig 1 is from one of the students' ePortfolios and visualizes how the course was organized in the ePortfolio with assignments submission (artifacts), and reflections. In this particular case, the reflection of assignment 2 were selected and shown in the right pane of the figure.

2 Work assignment 1 Computer supported co-operative work (CSCW2)	
1. Team Contract	Reflection
2. Computer supported co-operative work (CSCW)	CSCW
3. User-centered development	The assignment was related to theoretical understanding and applying theory in practice through the tool Teams based on issues related to collaboration technology (coordination and situation awareness).
4. Scenarios and personas	We first discussed what we should do and distributed tasks in the group to solve the task. We held several group meetings to discuss progress and further work. My job in the group work was to investigate topics related to situational awareness in Teams. In addition, I have helped to compile the final answer and was responsible for submitting the assignment at the right time.
5. The website in Office 365/Sharepoint	I learned how I could use theory from CSCW to assess which technology is most suitable for collaboration based on the group that will use the technology. Collaboration is performed today in many companies using collaboration technology, so it will be very relevant for me to have an overview of and knowledge about collaboration technologies and what it takes to succeed.
	I can help improve collaboration processes in a work context by analyzing which tools are best suited. I can also analyze which actors and main functions the collaboration should consist of for more efficient collaboration in an organization.

Fig. 1. An example of the organization of the course in the ePortfolio.

In the spring semester 2021, Course C had 55 students divided into 15 assignment groups, whereas Course W had 26 students working in altogether 8 groups. In total, 81 students participated in the two courses, and 67 students gave informed consent to participate in the study.

B. Research site and context of the case

For the spring semester 2021, we made the following changes:

- Due to the COVID pandemic, both courses were conducted in the digital classroom integral to the LMS.

- Each assignment was extended to include an individual reflection part, which was to be entered into the ePortfolio. The ePortfolios would then be the basis of individual assessment (pass/fail) in the courses.

- The first assignment included setting up the portfolio itself (integral to the LMS in use in the course). A link to the individual ePortfolio was to be included in each of the submitted group assignments. The individual reflection was based on an established approach to reflection (the what- so what- now what model), relating explicitly to achieved competencies and learning outcomes. The following guiding questions were added to each assignment:

- What did we do / what was the assigned task?
- What was my contribution to the group work?
- What did I learn from the assignment?
- How can I apply what I have learned to a future job context?

- The main part of the teachers' feedback on the assessments would be directed at the work done in the group. Additionally, feedback was to be given on the students' individual reflections from the ePortfolios. The feedback on the individual reflections was given at the same time as the feedback on the group work and was visible to the whole group. The form of this feedback was intended to acknowledge and encourage the reflection while not judging the contents.

- After the five assignments, there would be a final individual exam assignment (pass/fail) for the students with a summative reflection on learning, the reflection activities, and the use of ePortfolio and other aspects of the course. The students would get a passing grade if they answered the questions sufficiently well. The following guiding questions were added in the exam assignment for research purposes:

- 1 What do you think are the three most important things you have learned in this course?
- 2 What do you think about the reflection tasks throughout the course in terms of your own learning and your own awareness of what you have learned?
- 3 Did you understand the purpose of submitting work assignments in the ePortfolio and writing associated reflections?
- 4 If you had to select between the two options below, which option would you prefer and why?
 - Assignments (with reflection) and feedback take place in the ePortfolio.
 - Assignments (without reflection) are delivered in the LMS as you are used to.

The exam was conducted in the digital exam system Inspira Assessment.

C. Data collection and analysis

The data collected and reported on in this study are from students' ePortfolios, individual reflection assignments, and summative reflection from the exam assignment. In total, 67 students gave informed consent to participate in the study. For each student, we analyzed five assignment reflections

(ePortfolio reflection) and one individual exam assignment for each student (summative reflection). Table I summarizes data collected and analyzed.

TABLE I. DATA ANALYZED

Data	Analysed	Number of reflections
Assignments	ePortfolio reflection	67*5 (335)
Exam assignment	Summative reflection	67

In contrast to the summative reflections, which provide in-depth information, the ePortfolio reflections show if the experiences described in the summative reflections are consistent with the students' ePortfolio reflections.

Three (3) researchers were involved in the project. The first author designing the use of ePortfolio in the course and had no relation to the students apart from information provided about the research. The second author was a teacher in the course, while the third author had no connection to the course.

The students' reflections were downloaded from Inspira and anonymized before being imported into NVivo for thematic analysis and coding by the first author. The data analysis was performed in sequential steps with several levels of analysis [52]. We applied Tesch's Eight steps [53, pp. 142-145] in the coding process to identify codes with a combination of predetermined topics and emerging topics, starting with getting a sense of the data by reading through all the reflections. The first eight summative reflections were read to identify underlying meanings in the information and write thoughts in a separate document in NVivo. Related topics then were clustered together and abbreviated as codes. To see if new codes and categories should be added, we tested the preliminary organized scheme. Next, we turned topics into themes to group associated related codes to avoid unstructured codes without context. Fig. 2 presents the high-level code structure.



Fig. 2. The high-level code structure.

D. Ensuring quality of the study

The data were cross-examined and read by multiple scholars to support reliability, and additional themes were added based on agreement between the researchers when a new code was discussed. The second author examined the themes and codes identified in the first eight reflections, and lessons from the evaluation were implemented before continuing with the coding of all the students' reflections. These reflections were then analyzed, and themes and codes were cross-checked through periodic and shared observations. The students' reflections were analyzed separately to ensure that the codes were in line with the associated context. Only the second author was involved in teaching and grading. The students' summative exam was assessed before analyzing the data. In addition, the second author did not gain access to the data until after anonymization.

We have provided detailed descriptions in reporting on the study to contribute to trustworthiness so that readers can draw informed conclusions about applicability in their contexts [46]. As summative reflections are self-reported data, they have limitations because people tend to be biased when they report their own experiences [54]; therefore, we have used the students' ePortfolios for triangulation. Ethical approval was granted by the Norwegian Centre for Research Data (NSD) (279991). Examining the data from the summative exam, our subjective view is that students were not afraid to be honest. We have however no guarantee that everyone was. In addition, there are some limitations to the case study methodology, where only one institution is involved. Future research is needed to explore the results from this study in other educational contexts.

IV. RESULTS

Our analysis shows that most students prefer the ePortfolio (70%) over the traditional LMS folder assessment method (16%), but some students suggested a middle ground between the ePortfolio and the traditional LMS folder assessment method. From the thematic analysis, we identified results along two central dimensions of formative assessment with ePortfolio, corresponding to the posed research questions. First, as a *product*, the ePortfolio provided students with a comprehensive overview of achievements across topics, modules, and assignments in the course. Second, as a *process*, students became able to assess their performance, gained increased professional identity, and developed transferable metacognitions skills, which made students more aware of what they had learned in the course and made them able to connect learning to a job context. Further in this chapter, we look at findings related to the preferred formative assessment method of the two essential dimensions of formative assessment with ePortfolio.

A. Preferred formative assessment method

The observation of the students' portfolios showed that although the students were not used to ePortfolios, adding artifacts, and writing reflections, they quickly adopted the method. When asked which solution they prefer: the traditional LMS folder assessment method or the ePortfolio, only a few students say they prefer the traditional method. Table II shows an overview of the number of students who prefer the different assessment methods.

Although students were given only two alternatives, the traditional LMS folder assessment method and the ePortfolio, some students (11%) added a third option: The traditional LMS method with reflection. In addition, a few students (3%) believed that if assignments were to contain reflections, it was irrelevant whether the assessment took place in an ePortfolio or by using the traditional LMS folder assessment method.

TABLE II. PREFERRED ASSESSMENT METHOD

Assessment methods	Preferred assessment method	Text excerpts from the students' summative reflections
The ePortfolio	70%	<i>"The ePortfolio is a proof of learning that is otherwise difficult to obtain with grades."</i>
The traditional LMS method	16%	<i>"I prefer assignments in the LMS that we are used to because it is the method, we have used throughout the study program. It may be beneficial to use the ePortfolio, but if it is introduced just to get a change, I think it is unnecessary and confusing."</i>
The traditional LMS method with reflection	11%	<i>"I think it is best with the LMS method but combined with reflection. I think it is great to conduct self-assessment, but I am more used to submitting in the LMS."</i>
Irrelevant	3%	<i>"If the assignments are to contain reflections, I believe that they should be delivered at the same time, regardless of whether it is with a portfolio or as an additional document in the submission through the LMS."</i>

B. Comprehensive overview

The comprehensive overview was one of the reasons why most students (70%) preferred ePortfolio over the traditional LMS folder assessment method. Another reason the students themselves describe is that they experienced that the development of the ePortfolio made them more aware of what they have achieved through the course. In particular, they pointed out that through the ePortfolio and the reflections, they became able to see the relevance of what they learned related to a job context. In the summative reflection, several students pointed out that this was a completely new experience for them that they had never experienced in other courses.

The students who prefer the traditional folder assessment in the LMS justify it with the increased workload of using the ePortfolio, that they are not used to the ePortfolio, and that the ePortfolio is not used in other courses. These students' summative reflections indicate that they may not have understood the purpose of developing an ePortfolio. Arguments such as "the ePortfolio are not used in other courses" and "the ePortfolio is perceived as a change just to get a change in the course" confirm that the purpose is not perceived. The increased workload is also pointed out by some students who prefer the ePortfolio. However, these students experience such great value of the ePortfolio for their learning that increased workload is not perceived as a challenge. These students experienced the comprehensive overview as particularly important for their learning because layers of learning and achievements became visible across topics,

modules, and assignments in the course. The comprehensive overview also appeared to the students as important when they apply for a job in the future, as this student describes:

"The e-portfolio has increased my understanding of what I learned and led me to see the relevance of what I learned in a job context. When applying for a job, it is important to emphasize your competencies. The ePortfolio and the reflection notes have given me a comprehensive overview of achievements and made me more aware of my competencies as I now know how I can present to an employer."

One argument that often appears in the students' summative reflection is the contrast they experience between the ePortfolio, and the feedback and assessment linked to the LMS folder structure when they try to get a holistic picture of their learning outcomes. One student describes the difference between the traditional method and the ePortfolio as follows:

"Submissions in Blackboard, as we are used to, are not organized in an effective way. I constantly have to navigate in and out of different assignments and folders, and it does not give a complete picture of the total learning outcome I have received from the courses. The e-portfolio, on the other hand, provides an overall picture that acted as a motivating factor concerning the effort I put into the course."

C. The ePortfolio as a process

1) Self-assessment

Many students (84 %) describe that the process of reflecting on the artifacts made them more aware of what they had learned and how they could relate it to a job context. Students describe this experience as a factor that motivated them to learn and improve their performance in the course. When they saw through the reflections how what they had learned could be relevant to a particular job context, the motivation to improve their performance in the course increased.

In addition, multiple students experienced that the ePortfolio facilitated self-assessment as they became aware of what they have learned and able to plan improvements for future assignments (i.e., metacognition in relation to learning which helped the students to recognize strength and needs). According to these students, four aspects linked to the process of developing ePortfolios served as tools for self-assessment: the intended learning outcomes, the formative feedback provided by the teachers, access to fellow students' reflections, and fellow students' feedback from the teachers. In the first instance, before submitting the assignment, the students assessed their work against the learning outcome. Then, they assessed their work against feedback from the teacher and feedback fellow students received from the teachers, as the following quote illustrates:

"The learning outcome helped me evaluate what I experienced that I had learned and wrote in the reflection before submitting the reflection. It was also helpful to read fellow students' reflections and the feedback other students received as it gave me several different types of feedback that I could take with me to the following assignment: mine, the others, and the teachers."

Fig. 3 shows how students initially assessed their achievements described in their reflections against the intended learning outcomes, and then after submission, they assessed their work against feedback from the teachers and further assessed their work against fellow students'

How can I apply what I have learned to a future job context? The first reflection is from assignment 2, and the second reflection is from assignment 4:

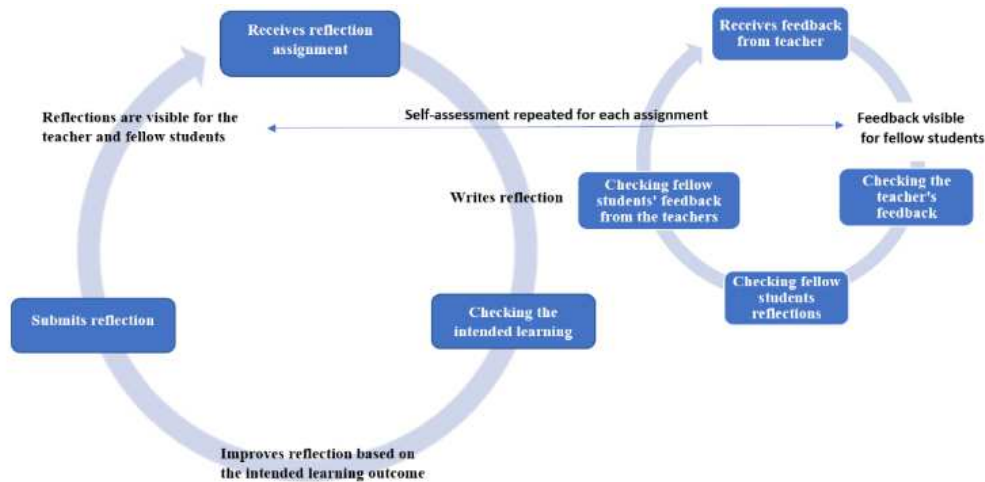


Fig. 3. The two-step self-assessment process.

reflections and the teacher's feedback to these reflections. The arrow between step 1 and step 2 represents how the students bring experiences in one assessment cycle into the next one. Thus, the two-step self-assessment is repeated separately for each assessment.

The most significant challenge the students saw in the fact that the reflection was visible to fellow students was that many students might hold back if there were disagreements in a group. Interestingly, in making this point, the students do not write anything about having experienced this themselves, but they think that those who experience disagreements in their group *might* have written about it if the reflections were not visible to others. On the other hand, none of the students mentioned in the summative reflection that they experienced disagreements, although the summative reflection was not visible to fellow students.

2) Metacognitions skills and professional identity

The students' summative reflections reveal that the guiding questions provided for the ePortfolio reflections worked well for most of them. However, the students' ePortfolio revealed that most students experienced some challenges initially. It was especially challenging for the students to relate learning to a job context. As the individual reflections in the ePortfolios indicated that students might not have read the learning outcomes described for the course before writing the reflections, they received a reminder in the initial feedback to read the learning outcomes. In the summative reflection, some students confirmed that they did not use the learning outcomes when writing reflections because they forgot to do so. These students point out in their summative reflection that there should have been given more reminders throughout the course. However, as the students conducted more reflections, they became better at describing how they can apply what they learned in a job context (i.e., metacognition concerning connections to career).

The following examples are from one student's e-portfolio, where the student has reflected on the last guiding question:

"I have learned a lot through Assignment two. General competence in coordination is crucial for understanding the context and complexity of different tasks and situations. The knowledge will, among other things, provide a greater understanding of the situation and make it easy to deliver."

"The competence I have gained related to M365, and SharePoint is truly relevant if I get a job in a company that uses these solutions. At the same time, experiences with various IT solutions are probably meaningful experiences no matter what job I apply for after my education. In addition, I have learned about scenarios related to IT solutions, which enables me to implement excellent user-centered development. The different methods and working methods I have learned are relevant to use in a future job, especially related to developing different solutions focusing on the users."

A few students (6%) wrote in the summative reflection that they did not experience any benefit from reflecting. The students who say they did not experience any benefits from reflecting are the same ones who did not understand the purpose of developing an ePortfolio. These students' summative reflections are characterized by short answers and a small or no degree of reflection. It did not emerge from these students' summative reflections that they read fellow students' reflections or fellow students' feedback from the teachers. The summative reflection of those who confirm that they understand the purpose of both the reflections and the ePortfolio and reading other students' reflections and fellow students' feedback from the teachers are of better quality than the reflection of the students who did not. The following example is an excerpt from one of the students' who reflects on important skills learned from the course:

"Learning about user-centered development has taught me how to develop a website with the user in focus and

strategies to achieve this. I have also gained more knowledge about digitization and how to use digital solutions in a job context, which will allow me to plan more effective collaboration in an organization."

The quote above also illustrates two interesting findings. First, it relates to personal identity as the student sees him-/herself in a job context where the work the student performs is related to what the student learned in the course. Second, the students identified what they perceived as the most important learning. The students described in their own words what was the most important learning in the course. On top of that, several students also connected their learning to a job context in the same way as they were told to do in the ePortfolio reflections. Thus, these students' reflections indicate that they have begun to develop a professional identity.

In addition to the students' experiences described above, the students' summative reflection indicates that they have transferred the metacognition in relation to career to other contexts such as the summative reflection and to a job context. Without encouragement, several students (78 %) reflected in the same way in the summative reflection as they did in the ePortfolio reflections, which may indicate that the students have developed transferable metacognition skills through the course. Some students also point out that the reflections provide good training in explaining to employers what they can do after education.

V. DISCUSSION

We identified results within two central dimensions of formative assessment with ePortfolio that can enhance computing students learning experiences (RQ1): as a product, the ePortfolio provided the students with a comprehensive overview of what they have learned, and as a process, students became able to assess their performance, gain skills in relation to professional identity and developed transferable metacognition skills. What influences the students' preference regarding formative assessment method (RQ2) can be linked to both the two central dimensions: as a process, the ePortfolio created awareness of what the students had learned and as a product, the ePortfolio created a comprehensive overview of achievements across topics and assignments.

In many regards, our findings confirm previous findings about computing students' experiences. To begin with, our results strengthen the claim that the ePortfolio makes invisible learning visible to students [7, 8, 9]. Furthermore, the students experienced the reflections, as conducted in this study, challenging, which also aligns with previous findings [40]. Like students from other disciplines [9, 40], computing students will need guiding questions for reflection to make them able to connect past, present, and future.

Most challenging for the students were the last guidance questions, where students had to reflect on how they could apply what they learned to a future job context. As the students repeated the individual reflections throughout the course, it became easier for them to explain what they had done, how they did it, and why it was relevant in a job context. Reflections can encourage metacognition, which is often recognized when students are required to explain what

they have done, how they did it, and why it was important [43]. This was confirmed by our study. Our findings also point to the benefits of reflection as a repetitive assignment; reflecting on questions of the kind used in our study repeatedly through a course helped the students transform metacognitive skills into other contexts. As our study showed when the students were asked what the most important learning was, most of them linked it to a job context. Indications that they have developed transferable metacognition skills are confirmed by the fact that students describe the ePortfolio reflections throughout the course as training in explaining to employers what they can do because of their education. When computing students describe this experience as a factor that increased their motivation to learn and improve their performance in the course, our findings indicate that the development of metacognition skills connected to career facilitated by using ePortfolio for formative assessment can enhance computing students' learning experiences.

Another aspect of formative assessment with ePortfolio which this study has shown to enhance computing students' learning experiences, is the self-assessment process facilitated by the ePortfolio [40]. A key finding in our study is how the ePortfolio made students conduct self-assessment and improve their work based on fellow students' reflections and fellow students' feedback from the teachers without being encouraged to do so. It is not new that guidance questions such as those we used in this study facilitate self-assessment [9] or that formative feedback can facilitate the development of self-assessment skills [37]. However, a key finding in our study is that the ePortfolio encouraged students to conduct self-assessments without being asked to do so.

Formative assessment is not a new concept and has existed long before the ePortfolio appeared. The same applies to feedback, reflection, and learning outcomes described for courses and study programs. Likewise, it is possible to organize reflections through courses, feedback, and processes for self-assessment without an ePortfolio. However, another key finding in our study is that students experience that the ePortfolio provides a much clearer picture of the total learning outcome achieved than the traditional LMS folder assessment method. The advantage of formative assessment with ePortfolio was perceived by most students as so valuable for their learning and relevant for the future when applying for a job that they would select the ePortfolio over the traditional LMS method even if the ePortfolio increases the workload.

The course described in this paper was conducted digitally due to the COVID pandemic; however, formative assessment with ePortfolio can be performed in the same way in classroom teaching as in a digital environment. For instance, the study by Ring, Waugaman, and Brackett [9], and Slepcevic-Zach, and Stock [40] are case studies conducted in physical classrooms.

A. Implications and recommendations

Based on our findings, we would like to highlight five implications for educators who plan to integrate ePortfolio for formative assessment. The presented recommendations can also work as pointers for future research since whether they do have a positive effect on formative assessment and

students' development of e-portfolio remains to be investigated.

1) *The intended learning outcomes.* Because the intended learning outcomes are what the students will learn and prove that they have achieved in assignments, and further is an essential tool for students' self-assessment process, the intended learning outcomes should be easy to access. By adding the learning outcome to the ePortfolio, students get easy access to it, and the students will also be reminded to look at the learning outcome when writing reflections.

2) *Self-assessment.* We can not assume that students in fact evaluate their work even if given tools through the ePortfolio that simplify the self-assessment process. However, teachers can motivate students to look at fellow students' work and fellow students' feedback from teachers, e.g., when the ePortfolio is introduced to the students or through mandatory peer review. For further research, we recommend looking more closely at a more strategic way to carry out the two-step self-assessment process and, in addition, how to implement the two-step process in courses that do not involve group work.

3) *Visible reflections.* Some students may feel uncertain or anxious when asked to share their reflections with fellow students. In our study, one of the reasons the student became better at explaining what they are capable of was by reading fellow students' reflections. When graduating and applying for a job, employers will ask them to explain what competencies they hold as they have practiced in their reflections to become better at focusing by reading fellow students' reflections. To institutions and teachers planning to introduce the ePortfolio for their students, we recommend addressing the benefits by reading fellow students' reflections and visualizing their value of this type of practice.

4) *Motivation/encouragement.* There will always be students who do not use all the available resources for self-assessment unless they are directly encouraged. Therefore, there should be more focus on engaging all students in reading each other's reflections, e.g., through mandatory peer assessment, even if giving students access to see fellow students' reflections in itself can encourage self-assessment.

5) *Formative assessment values and the ePortfolio.* One of the benefits of formative assessment is the feedback students receive during a course that enables them to see what they know and what they do and plan for improvement. Our study found formative assessment values achieved without much teacher involvement (e.g., plan for improvement because they gained access to fellow students' reflections). Further research should look at how the ePortfolio can extract some of the value in formative assessment in courses with a high number of students, where it is challenging to carry out such a form of assessment.

VI. CONCLUSION

This study has explored how formative assessment with ePortfolio can enhance computing students' learning experiences and what influences which method the students prefer of the ePortfolio and the traditional LMS folder assessment method.

The results along the two central dimensions of the ePortfolio as a product and process can enhance computing students' learning experiences through comprehensive overview, self-assessment, transferable metacognitions skills, and professional identity. As the students developed metacognition related to learning and carrier, they became motivated to learn and improve performance. When it comes to professional identity, one course will only provide just a piece of a holistic professional identity; however, we find that pieces of professional identity can also enhance computing students' learning experience as this was a motivating factor for improving performance.

A key finding in our study is how the ePortfolio made students conduct self-assessments. Such a finding is essential and shows the opportunities in the ePortfolio for computing students. Our study led to students improving their work without being encouraged or required to do so because, through the ePortfolio, they gained access to tools that enabled them to carry out self-assessments. The results within the two aspects were perceived as so essential by the students that most preferred formative assessment with ePortfolio instead of the traditional LMS folder assessment method.

REFERENCES

- [1] G. Joughin, «The hidden curriculum revisited: a critical review of research into the influence of summative assessment on learning,» *Assessment & Evaluation in Higher Education*, 35(3), 335-345, 2010.
- [2] N. E. Winstone og D. Boud, «The need to disentangle assessment and feedback in higher education,» *Studies in Higher Education*, 45, 1-12, 2020.
- [3] H. Johnsen, "Making Learning Visible with ePortfolios: Coupling the Right Pedagogy with the Right Technology," *International Journal of ePortfolio* 2(2), 139-148, 2012.
- [4] T. St Jorre and B. Oliver, "Want students to engage? Contextualise graduate learning outcomes and assess for employability,» *Higher Education Research & Development*, 37(1), 44-57, 2018.
- [5] B. Kensington-Miller, A. Longley, S. Sturm, A. Mead, A. Gilbert og B. Knewstubb, «Making the Invisible Visible Illuminating undergraduate learning outcomes beyond content and skills,» Ako Aotearoa – The National Centre for Tertiary Teaching Excellence, Wellington, 2019.
- [6] S. M. Janosik and T. E. Frank, "Using ePortfolios to Measure Student Learning in a Graduate Preparation Program in Higher Education," *International Journal of ePortfolio* 3(1): 13-20, 2013.
- [7] B. Eynon, G. M. Laura and J. Török, "What Difference Can ePortfolio Make? A Field Report from the Connect to Learning Project," *International Journal of ePortfolio*, 4(1), 95-114, 2014.
- [8] G. Kuh, K. O'Donnell and C. G. Schneider, "HIPs at Ten," *The Magazine of Higher Learning*, 49(5), 8-16, 2017.
- [9] G. Ring, C. Waugaman and B. Brackett, "The Value of Career ePortfolios on Job Applicant Performance: Using Data to Determine Effectiveness," *International Journal of ePortfolio* 2(1), 225-236, 2017.
- [10] P. Abrami and H. Barrett, "Directions for Research and Development on Electronic Portfolios," *Canadian Journal of Learning and Technology / La revue canadienne de l'apprentissage et de la technologie* 31(3), 2005.
- [11] A. Alexiou and F. Paraskeva, "Inspiring Key Competencies Through the Implementation of an ePortfolio for Undergraduate Students," *Procedia - Social and Behavioral Sciences* 197, 2435-2442, 2015.
- [12] L. Cordie, J. Sailors, B. Barlow og J. S. Kush, «Constructing a Professional Identity: Connecting College and Career Through ePortfolios,» *International Journal of ePortfolio*, 9(1), 17-27, 2019.

- [13] J. Bowman, B. J. Lowe, K. Sabourin og C. S. Sweet, «The Use of ePortfolios to Support Metacognitive Practice in a First-Year Writing Program,» *International Journal of ePortfolio*, 6(1), 1-22, 2016.
- [14] F. Rampelt, D. Orr and A. Knoth, "Bologna Digital 2020 White Paper on Digitalisation in the European Higher Education Area," *Berlin, Hochschulforum Digitalisierung*, 2019.
- [15] M. B. Fisher og A. J. Hill, «ePortfolio Adoption and Implementation in Multiple Campus University Environment», *Literacy Information and Computer Education Journal*, 6(1): 1821-1826.
- [16] EIfEL, "ePortfolio – a European Perspective," 2009.
- [17] O. Dysthe og K. S. Engelsen, «Portfolio practices in higher education in Norway in an international perspective: macro - , meso - and micro - level influences,» *Assessment & Evaluation in Higher Education*, 36 (1), 63-69, 2009.
- [18] G. Hallam, W. Harper, C. McCowan, K. Hauville, L. McAllister, T. Creagh, J. v. d. Lee, S. Lambert and C. Brooks, "Australian ePortfolio Project - ePortfolio use by university students in Australia: Informing excellence in policy and practice," QUT Department of Teaching and Learning Support Services, 2008.
- [19] T. Skyttermoen, "Mer enn vurdering? Om digitale kompetansemapper i høyere utdanning," *Uniped* 34(4), 57-71, 2011.
- [20] O. Dysthe, K. S. Engelsen and I. Lima, "Variations in portfolio assessment in higher education: Discussion of quality issues based on a Norwegian survey across institutions and disciplines," *Assessing Writing*, 12(2), 129-48, 2007.
- [21] A. Steen-Utheim and T. N. Hopfenbeck, "To do or not to do with feedback. A study of undergraduate students' engagement and use of feedback within a portfolio assessment design," *Assessment & Evaluation in Higher Education*, 44(1), 80-96, 2019.
- [22] R. Esterhazy, M. Nerland and C. Damsa, "Designing for productive feedback: an analysis of two undergraduate courses in biology and engineering," *Teaching in Higher Education*, 26(6), 806-822, 2021.
- [23] M. Bader, T. Burner, S. H. Iversen and Z. Varga, "Student perspectives on formative feedback as part of writing portfolio," *Assessment & Evaluation in Higher Education*, 44(7), 1017-1028, 2019.
- [24] A. Mihai, Q. Fredrik og Z. Chang, «Portfolios in Political Science: The Interplay Between Independent Learning Space and Collective Knowledge Building,» *International Journal of ePortfolio*, 11(1), 11-24, 2021.
- [25] Independent Group of Scientists appointed by the Secretary-General, «Global Sustainable Development Report 2019: The Future is Now – Science for Achieving Sustainable Development,» (United Nations, New York,), 2019.
- [26] P. Black and D. Wiliam, "Assessment and Classroom Learning," *Assessment in Education: Principles, Policy & Practice* 5(1), 7-74, 1998.
- [27] B. Cowie and B. Bell, "A Model of Formative Assessment in Science Education," *Assessment in Education: Principles, Policy & Practice*, 6(1), 101-116, 1999.
- [28] K. Fuller, "Beyond Reflection: Using ePortfolios for Formative Assessment to Improve Student Engagement in Non-Majors Introductory Science," *The American Biology Teacher*, 79 (6), 442-449, 2017.
- [29] M. Welsh, "Student perceptions of using the PebblePad eportfolio system to support self- and peer-based formative assessment," *Technology, Pedagogy and Education*, 21(1), 57-83, 2012.
- [30] E. Ehiyazaryan-White, "The Dialogic Potential of ePortfolios: Formative Feedback and Communities of Learning Within a Personal Learning Environment," *International Journal of ePortfolio*, 2(2), 173-185, 2012.
- [31] A. Rushton, «Formative assessment: a key to deep learning?,» *Medical Teacher*, 27(6), 509–513, 2005.
- [32] R. D. Sadler, «Beyond feedback: developing student capability in complex appraisal,» *Assessment & Evaluation in Higher Education*, 35(5), 535-550, 2010.
- [33] G. Gallagher, "Aligning for Learning: Including Feedback in the Constructive Alignment Model *," *AISHE-J All Irel. J. Teach. Learn. High. Educ.*, 9(1), 3011–30112, 2017.
- [34] J. Hattie and H. Timperley, "The Power of Feedback," *Review of Educational Research*, 77(1), 81-112, 2007.
- [35] M. Yang, M. Tai and C. . P. Lim, "The role of e-portfolios in supporting productive learning," *British Journal of Educational Technology* 47(6), 1276–1286, 2015.
- [36] G. W. Scott, «Active engagement with assessment and feedback can improve group-work outcomes and boost student confidence,» *Higher Education Pedagogies*, 2(1), 1-13, 2017.
- [37] D. J. Nicol og D. Macfarlane-Dick, «Formative assessment and self-regulated learning: A model and seven principles of good feedback practice,» *Studies in Higher Education*, 3(2), 199-218, 2005.
- [38] J. H. McMillian and J. Hearn, "Student Self-Assessment: The Key to Stronger Student Motivation and Higher Achievement," *Educational Horizons*, 87(1), 40-49, 2008.
- [39] S. Carter, «ePortfolios as a platform for evidencing employability and building professional identity: A literature review,» *International Journal of Work - Integrated Learning*, 2(4), 463-474, 2021.
- [40] P. Slepcevic-Zach and M. Stock, "ePortfolio as a tool for reflection and selfreflection," *Reflective Practice*, 19(3), 291-307, 2018.
- [41] H. Braund og C. DeLuca, «Elementary students as active agents in their learning: an empirical study of the connections between assessment practices and student metacognition,» *The Australian Educational Researcher*, 45, 56-85, 2018.
- [42] J. A. Bokser, S. Brown, C. Chaden, M. Moore, M. N. Cleary, S. Reed, E. Seifert, L. B. Zecker og K. Wozniak, «Finding Common Ground: Identifying and Eliciting Metacognition in ePortfolios Across Contexts,» *International Journal of ePortfolio*, 6(1), 33-44, 2016.
- [43] H. Hartman, "Developing Students' Metacognitive Knowledge and Skills," *Metacognition in Learning and Instruction*, 19, 33-68, 2001.
- [44] V. Klenowski, *Developing Portfolios for Learning and Assessment: Processes and Principles*, vol. 1st, London and New Yourk: Routledge, 2002.
- [45] . A. . O. Akturk og I. Sahin, «Literature Review on Metacognition and its Measurement,» *Procedia - Social and Behavioral Sciences*, 15, 3731-3736, 2011.
- [46] S. Ferns og J. Comfort, «ePortfolios as evidence of standards and outcomes in work-integrated learning,» *Asia-Pacific Journal of Cooperative Education*, 5(3), 269-280, 2014.
- [47] C. P. Tan, Van der Molen og H. G. Schmidt, «A measure of professional identity development for professional education,» *Studies in Higher Education*, 42(8), 1504-1519, 2015.
- [48] C. Guder, «The ePortfolio: A Tool for Professional Development, Engagement, and Lifelong Learning,» *Services Quarterly*, 9, 238-245, 2013.
- [49] M. J. Graham et al, "Increasing Persistence of College Students in STEM," *Science*, 341(6153), 1455-1456, 2013.
- [50] M. M. V. Svyantek, R. L. Kajfez og L. D. McNair, «Teaching vs. Research: An Approach to Understanding Graduate Students' Roles through ePortfolio Reflection,» *International Journal of ePortfolio*, 5(2), 135-154, 2015.
- [51] The Ministry of Education and Research, "The Norwegian Qualifications Framework for Lifelong Learning (NQF)," NOKUT, 2014.
- [52] J. W. Creswell and D. J. Creswell, *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*: Los Angeles, SAGE, 5 ed., vol. 5, SAGE Publications Ltd, 2018.
- [53] R. Tesch, *Qualitative Research: Analysis Types and Software Tools*. New York, Falmer, 1990.
- [54] M. Devaux and F. Sassi, "Social disparities in hazardous alcohol use: self-report bias may lead to incorrect estimates," *European Journal of Public Health*, 26, (1), 129-134, 2015.