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Learning through collaborative design	4
of location-based games	5
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Abstract This paper describes the design, deployment, analysis, and evaluation of a learning scenario focused on exploring the educational potential of location-based games. Through its design and rationale, the scenario serves as an illustration of how students can learn through the collaborative design and playing of location-based games. It involves an exploration of the pedagogical potential of students as game designers, through a study of students designing	9 10 Q3 11 12 13 14
location-based games for peers in order to learn history. This shows the potential of using both authoring tools to have students engage creatively with subject matter and as a focal point of collaborative learning activity. As the topic of the scenario revolved around learning about history, we also found that the ways they relate to this topic when using location-based games offers a new way of integrating curricula in learning activities, and that it is key to think beyond a single subject and look at cross-curricular elements and goals in such scenarios. We offer a very detailed description and analysis of the practical accomplishment of the learning activities involved in	15 16 17 18 19 20 21
the collaborative design of location-based games.	22
Keywords Learning through design \cdot Game design \cdot Location-based games \cdot History learning \cdot Design research \cdot Constructionism \cdot Video analysis	23 Q4 24 25
Introduction	26 Q5
When Papert (1980) and his colleagues launched the Lego Mindstorms program, they did not only introduce a new technology for supporting learning, but also a vision of how students	27 28

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should take on the roles of designers or constructors, and engage with the topics at hand in a
creative manner. Papert's vision of constructionism has had some influence on the field of
3030CSCL (see Laurillard 2009), and especially on the ideas of knowledge building (Bereiter and
Scardamalia 2006). In this paper we argue that the idea of having students create shareable
artefacts as a way of engaging in meaning creation and as a way of exploring a topic, might
still have an unexplored potential in CSCL.34

The study presented here explores how high school students participate in a learning 35scenario involving design and creation of location-based games for learning about history, 36 the playing of such games and creation of multimedia presentations based on their experiences 37 and documentation of their own game play. While we have studied all phases of this scenario, 38 this paper puts extra emphasis on students as *faber ludis*; in the phase where students create 39location-based games for each other. In particular, we are interested in what kind of activities 40 and how the actual collaborative design of location-based games is accomplished in practice. 41 Having students engage in design activities involves a certain way of relating to the subject 42matter, and might shift focus from history to other competencies, such as collaboration and 43digital literacy. 44

There is both a need to understand how learning scenarios with location-based games can be designed and integrated with school practices, and to understand the practical details of the interaction that emerges in such learning scenarios. To develop an understanding of the educational potential of location-based games, they need to be deployed in practical educational settings. To get to grips with how these technologies are adopted into the collaborative learning activities of the students, there is a need to empirically examine how the students organize their interaction when using the tools (Guribye et al. 2014; Koschmann et al. 2007). 51 Q6

Another challenge is how we can integrate production and authoring tools in learning 52 activities in formal education. This involves understanding how we can create learning 53 scenarios that incorporate students' use of authoring tools in design activities in school 54 settings. This also involves understanding how to integrate these activities with existing school 55 practices, (Wake 2013), with curricular and institutional arrangements, and into the existing infrastructure for learning (Guribye 2015). 57

To address the above issues, we have designed and deployed a learning scenario where the 58 students take the role of designers of location-based games for learning history. In this scenario 59 the authoring tool (SILO) played a central role – enabling the students to easily create locationbased games in a collaborative effort. Furthermore, we have conducted a detailed analysis of 61 the students' interaction in this activity. The main research question in this study is *How can* 62 *collaborative design of location-based games support history learning?* More specifically, we are interested in: 64

- i) How can we design a learning scenario where students are engaged in designing locationbased games in a school setting?
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- ii) How do the students organise their interaction, and how does learning emerge in the 67 design process of such a scenario?
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To address these questions, this paper describes how upper secondary students use an authoring tool for location-based games to creatively and collaboratively design games and other media in order to learn history. We address how the students make design decisions and coordinate their work when participating in a learning scenario involving collaborative design of location-based games for learning about history. The learning scenario was developed in 73

collaboration with a history teacher where groups of students create a game, receive and play 74 another group's game, and create a media product based on their experiences in the previous 75activities. The analysis of the video-based empirical material shows how the students engage 76creatively with the learning material and describes the interactional organization of the process 77 of designing games for another group of students. We further address the students' practical 78accomplishment of game design and how they engage in a design process where they integrate 79curricular and other historical source materials, and place these in a narrative by constructing a 80 number of points of interest in the location based-game. They are thus taking into account 81 historical events, the layout of different locations, the playability of the game, and the actual 82 game mechanics supported by the location based-game authoring tool. The location-based 83 gaming experience was intended to feed into the creation of a media product that enables 84 students to demonstrate their learning experience. 85

The organization of the paper is as follows. First, a literature review focusing on use of 86 games for educational purposes, mobile and ubiquitous technology in the field of CSCL is 87 presented. Then, the learning scenario including student activities and the main technology 88 they used is accounted for. Next, we present the research methods used. Then we present the 89 empirical findings on the deployment of the scenario and the analysis of transcripts of student 90 activity. Finally, we discuss the implications of our study. 91

Approach and relevant studies: Designing mobile, location-based games for learning

The use of mobile technology to support collaborative learning has a history within the field of 94 CSCL (e.g., Roschelle and Pea 2002; Roschelle et al. 2005). Tools have been developed and 95studied, both to support collaboration in the classroom (Chang et al. 2009; White 2006), and to 96 provide support when moving into the field (Lyons 2009; Yatani et al. 2004; Tan et al. 2007). 97 Computer games have also become increasingly used and studied for their educational 98potential, also within the field of CSCL (e.g., Enyedy et al. 2012, 2015; Ke 2007, 2008; 99 Rosenbaum et al. 2007; Satwitcz and Stevens 2007; Klopfer et al. 2005; Bennerstedt & Linderoth, 2009). 101

A trend within digital technologies is that easily accessible tools for designing and 102authoring digital materials and content, such as web pages, blogs, videos, 3D objects, music 103and also games are proliferating. These production and authoring tools mediate a shift where 104users are not only being consumers of digital materials, but also producers. This turn has for 105the last decade figured under different labels such as Web 2.0 (Kang and Glassman 2011; 106Bonderup Dohn 2009), prosumer culture (Jenkins et al. 2006), produsage (Bruns 2007) 107peer/social/fan production (Corneli 2014; Edfjeldt et al. 2006), tinkering (Wilkinson and 108Petrich 2014; Gabrielson 2013), making (Brown 2015; Martinez and Stager 2014) and 109metadesign (Fischer 2009; Fischer and Herrmann 2015). 11008

In the context of computer-supported collaborative learning Forte (2014) argues that to 11109 integrate "participation in information production into formal education" (p. 49) provides one 112way of helping students look critically at the content of new information environments. Further 113she claims that letting students create information for others "effectively introduces an 114 authentic need for accuracy and students have been shown in this study and others to adopt 115new, creative strategies for sourcing and critiquing claims." (p. 49). While Forte's (2014) 116claims are mainly limited to the production of information and texts, we argue that this line of 117

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reasoning resonates more broadly with "design thinking" (Cross 2011) and "designerly ways 118 of knowing" (Cross 1982). Following the same line of argument and relating to design 119**Q10** thinking, Kim et al. (2015) introduce the notion of *learner-generated designs* and argue that 120these designs "provide opportunities for learners to bring in their objects or ideas of signifi-121cance to engage in pedagogic discourse with their peers and teachers or mentors" (p.545). 122Thus, this strategy is not only a new way to engage with content matter or the topic at hand, 123but also a way to organize learning activities that provides an opportunity to engage in 124collaboration and meaning making with peers and teachers. 125

Using the strategy of placing students in the position of being designers and producers of 126 digital materials and content for the purpose of learning, however, brings on a specific set of 127 challenges. One such challenge is the students' digital literacy. Weilenmann et al. (2014) 128

"argue that as the notion of literacy shifts towards participation and the ability to130produce media content, rather than just consuming it, and as the tools for production131become more powerful and diverse, the skills needed to participate will be increasingly132medium specific" (p. 749).133

Weilenmann et al. (2014) describe a study of collaborative video editing in an informal 135setting, studying how users develop skills when engaging with the video-editing tool. The 136 video editing tool is seen as an example of emerging means of communication that has 137 relevance on a societal level. Learning to communicate through the video editing tool is hence 138regarded as a formative experience, with relevance for participation. The emerging prevalence 139of such digital tools of representation makes it pertinent to reconsider the "nature of literacy" 140(p. 738), as it represents changes in the conditions for expression. Sharples et al. (2009), from 141011 the perspective of mobile learning, describe the skills required in a learner for operating these 142emergent conditions as being able to navigate "multiple contexts", for example. Forte (2015), 143concerned with the formation of online collaborative writing, through for example blogs and 144wikis, argues that creating information for others introduces an authentic need for accuracy. 145Weilenmann et al. (2014) make the argument that mastery of tools for meaning making, 146participation, and expression requires exposure to and experiences with the tools - it is 147 something that "has to be learned" (p. 738). Furthermore, to design information using media 148149tools requires more knowledge and experience than consuming or interpreting information. Rather than merely providing access to tools, it is important that use situations including 150purpose and context are carefully designed. They find that appropriation of the necessary skills 151relies on collective work and in situ sharing of experiences, and that the video editing has a 152performative quality - the students are held accountable for their work in a different way than 153when compared with traditional learning tasks. 154

Salen and Zimmerman (2004) write that a major design challenge in computer games lies in 155striking the balance between *challenge for* and *ability of* the intended user. When a challenge is 156presented as a problem to be dealt with, a user experiences anxiety until the problem is 157overcome. When a problem or task is perceived as too easy, the user will experience boredom, 158although Brown and Juhlin (2015) note that sometimes game players will complete unchal-159lenging tasks repeatedly without becoming bored. Problems that are perceived as impossible to 160solve will also lead to boredom and quitting. Challenge and skill furthermore represents a 161162dynamic pair, as challenges that are overcome increase the player ability and skill. The challenges should thus have an increasing level of difficulty and novelty throughout the game. 163

Many of the educational initiatives towards design and creation of computer games concern 164 computer game design (Salen and Zimmerman 2004) itself, rather than using the game design 165

process for students to learn other curricula (Kafai 2006; Kafai and Resnick 1996; Orvieto 166 2012). Constructionism (Papert 1980) provides a rationale for engaging students in game-167making as a learning activity (Holmes & Gee, 2015). Holmes and Gee (2015) introduce the 168012 concept of a "designing frame" of asserting that "the process of knowledge construction is 169enhanced when learners are required to express their ideas in the form of tangible artefacts that 170are shared with other people" (p. 12), requiring learners to make their ideas explicit. Kafai 171(2006) further adds that involvement with the game design process helps students develop 172technological fluency. Fluency involves more than learning facts, for example "making things 173of significance (...), and most important develop new ways of thinking" (p. 39). In this paper 174we discuss the medium specific challenge of how to engage students as designers of location-175based games. 176

One example study that looks at both game design and game play is El-Nasr and Smith's 177(2006) two case-studies of students in computer science learning computer skills through 178modifying, or *modding*, existing games by working with the game engines. They found that 179game development involves many different skills other than programming, ranging from 180artistic to mathematical concepts. Lim (2008) raises the idea that students in school should 181 be allowed to design their own computer games based on their own interpretations of the 182curriculum as a way to create more engagement with their own learning processes. Resnick 183(2007; Resnick et al. 2009) describes Scratch, which is an online system where students learn 184to program interactive, online media products such as games, stories and animations, designed 185to foster creative and systematic thinking. 186

Schwarz and Stoecker (2012) describe the process of Learning Game Design as a relative187new craft where game design and didactic design are combined. The design of a learning game188potentially involves a number of activities, including story-, visual-, sound-, interaction-,189information and character design.190

Sengupta-Irving and Enyedy (2015) carried out an empirical/observational study of student 191engagement within two comparative student groups: teacher guided vs. student-driven inquiry 192in mathematics. While the learning outcomes or test results for the students in two groups were 193insignificantly different, they found that the students in the student-driven and open approach 194generally displayed more signs of engagement. By studying video recordings of students 195working to solve mathematical problems, they found that students who had more autonomy in 196 leading their own inquiry displayed three kinds of behaviour that were less apparent with the 197 students in the teacher-guided group, namely: strategy talk, questioning of the content and 198meaning-making. Strategy talk refers to bringing up new ideas when faced with a problem. 199

It can be argued that this difference references something that is unique in teaching and 200 learning history. Mills Kelly (2013) discusses the concept of *historical thinking* involved in 201 teaching and learning history, and how knowledge of history involves something more than, 202 for example, knowing historical facts and figures. He argues that by giving students freedom to 203 experiment and produce related to historical sources, there are significant learning gains to be 204 had, including that of engagement. One of the ways to facilitate such playfulness is to give 205 access to digital tools and media. 200

FitzGerald (2012) describes a study of an authoring tool for guiding the creation of usergenerated content with location-based services, focused on how non-trained facilitators can provide appropriate information to support learning and teaching. Through the application of six general principles - landscape domain, type of communication, use of language/media, knowledge level of content, contextual aspects, and interaction to include - she analysed existing user-generated location-based content from a variety of sources. She argues that this

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Research methods

The overall research approach is based on creating and deploying learning scenarios inspired 219 by design-based research (Barab and Squire 2004). When attempting to introduce new digital 220 technologies to already established educational practices, there are always a number of 221 institutional, organisational, and pedagogical contingencies that have implications on how 222 the technology can become embedded. The technology implementation needs to be studied in 223 situ, which necessitates a practical approach. 224

In design-based research, the research endeavour is to transform an educational practice, 225here, engaging students as game designers, with commitment to improve said practice. Cobb 226013 et al. (2003) highlighted that design experiments "entail both 'engineering' particular forms of 227 learning and systematically studying those forms of learning within the context defined by the 228means of supporting them" (p. 9). Iteration of the design, implementation, and evaluation are 229central and vital elements in design-based research (Brown 1992). Collins et al. (2004) saw 230this iteration as "progressive refinement", which involves an initial testing of a design in the 231real world, after which constant revision of the design is carried through. The study reported 232here, represents one of several cycles of studying the educational potential of location-based 233 games (Wake 2013), where it is sought to understand how students themselves can take part as 234game designers for the purpose of learning history, where the particulars of the game 235technology are characterised by taking place in the real world, in the same place of which 236237they were learning the history.

The evaluation of the learning scenario includes an empirical study based on interaction 238analysis (Jordan & Henderson, 1996). The analysis is also inspired by studies where the use of 239014 240technological resources features as a central component in the analysis (e.g., Heath and Luff 2000; Suchman 2007). A key element in these studies is the use of video recordings in the 241analysis (Heath et al. 2010). Video-based research has gained momentum in CSCL and the 242learning sciences (for an overview see Derry et al. 2010). As Koschmann et al. (2007) point 243out, a key analytical commitment in such studies is "to discover within the recorded materials 244what the members are actually accomplishing (...) and are making relevant (...) through their 245interaction" (Koschmann et al. 2007, p. 7). The same analytical commitment guides the 246following analysis. 247

The main data source for this study was video, and the recordings form the basis for the 248 analysis in this paper. We chose to follow one group throughout the scenario. The group work 249 in class was concurrent, we wanted to obtain footage of the students' interaction in detail and 250 had one camera/researcher available. The choice of which group to follow was made on the 251 first day of filming and was made on the teacher's suggestion. It was also a pragmatic choice, 252 as they were seated at the front of the classroom with room for the camera setup (one of two 253 groups closest to the camera), and fewer sources of background noise. 254

A total of six sessions were filmed. These include the teacher's introduction, sessions which 255 consisted of reading and rewriting source material tied to places, sessions where they created 256

the game in the SILO interface, the session where they played their games, and the session 257where they created the media product. The recording of the activities resulted in a total of 12 h 258and 45 min of video footage. The main researcher was present during the filming, and the 259recorded material was digitalised and reviewed after each session. To support the analysis, all 260the video has later been coded into a detailed activity log, describing the activities that 261occurred, as recommended by Jordan & Henderson (1996). Most sections of talk and 262interaction have been transcribed. Based on a iterative review of all the transcripts by two 263researchers, identifying interesting examples and themes. The selection of the extracts pre-264sented in the analysis below is based on what the researchers found as illustrative of core 265activities involved in the collaborative design of location-based games, and is anchored in the 266ethnographic understanding of the scenario deployment as a whole. 267

Additionally, interviews and observation were carried out, and artefacts produced by the 268students were collected. The teacher and each student group were interviewed face-to-face two 269days after the scenario was completed. All interviews were recorded and transcribed in full. 270The groups that were not being filmed were observed while they worked, and field notes 271including which tools and sources they used, how they organised collaboratively, and so on, 272were recorded. Furthermore, the student products that were collected included the games that 273they created and the media product that they created. The games were copied from the SILO 274system to a file in a text editor, to be able to review them later. 275

The design of the learning scenario

To explore the educational potential of creative design of location-based games for history 277learning, a scenario involving different digital tools and activities was designed in close 278collaboration with the teacher. The scenario comprised three overall activities: Game creation, 279Game playing, and Media Product development. First, working in groups, the students were to 280tie historical themes in Bergen's history to actual places in Bergen, and combine these places 281and themes into a location-based game. Second, the students were to give their game to 282another student group to play. Third, after playing another group's game, each group should 283then build on their experiences with the different themes and locations in the game to create a 284media product. Through game creation the intention was that the students were to identify and 285combine features of the real world, represented by the different locations in the city, and their 286interpretations of the different written sources available to them, into a game narrative that 287would be discovered by the recipients as they played the game outdoors. The gaming aspect 288was about finding the locations in the game by following clues in the narrative. By creating a 289media product, the students were put in a position to reflect over and demonstrate what they 290learned about Bergen's history by playing another group's game. 291

Technological resources: SILO

The authoring tool the students used to create the games is called SILO. Originally SILO was293designed for Nokia, using Python for S60, which is the version the students in this study used.294The tool has later been redeveloped for iOS and Android, and a first basic, but working version295became available in 2014. SILO has previously been described in detail elsewhere (see296AUTHOR, AUTHOR, AUTHOR), so only a summary of the functionality is provided here:297(1) SILO consists of a web-based game authoring tool and an app on the phone for playing the298

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games. (2) SILO permits a game designer to construct a storyline as a set of missions, and299attach the different missions to different locations, by clicking on a map, displayed on the300screen. (3) The game creator can add icons to locations, set limitations on time, configure user301data, and a maximum of three hints on how to find each location.302

The mobile application converts the data into a game to be displayed on the mobile device 303 and lets the user interact using the following elements on the screen: (1) A scrollable map, an 304optional marker displaying one's current position on the map, an optional track displaying the 305 history of movement, and a game score. (2) A distance meter (shown in red and green 306 numbers), displaying the remaining distance to the next location, which is updated every five 307 seconds. When a player moves within a zone of 30 m around the location, the red numbers turn 308 green, and they are permitted to 'pick up' the Point of Interest (POI) in the game. (3) A 309progress bar displaying the icons representing the places that the participant has visited, and a 310 number of empty spaces, indicating game progress. (4) A menu system, to access the game 311score and "pick up" the available POI in the game. (5) A mission (i.e. a description of the next 312 location from the storyline). 313

While the game is being played the application is constantly calculating the distance to the next location. The distance is displayed in red until the players near the location and it turns green indicating they can pick-up the location. They are then offered information about the 316 current location and a text that describes the next location. The game then pauses, to allow the 317 group to think about what to do next, and an icon signalling that they have picked up the 318 previous location is displayed. The game is over when the last mission is solved (i.e. the last 319 location is found). 320

Themes for the game: WW2 in Bergen

The scenario was designed and planned in close collaboration with the teacher, both in terms 322 of the theme chosen and how to use the available technology for creating and playing the 323 location-based games. The participating teacher taught history, and was the "e-contact" at the 324school with expanded responsibilities related to the school's ICT-systems and helping the other 325teachers with digital technology. She chose Bergen history during the 2nd World War (WW2) 326 as the theme for the game as 1) it was a good fit with their current curriculum, which was 327 between "older" and "newer" history, 2) the school building was occupied by the German 328military during WW2, and 3) the availability of physical locations related to the theme around 329 Bergen. The teacher identified themes and events related to 16 locations in Bergen during 330 WW2. Examples of the themes include: 'The attack on Bergen on April 9th, 1945. Where?', 331 'The Printed Press of Bergen during times of crisis: Illegal papers', 'The history of Jews in 332 Bergen', and 'Food and rationing'. 333

Phases in the scenario

The learning scenario was organised around three main phases:

Game Design Activity: The class was divided in half, with each half being given a list of eight of the themes. Each half was further divided into groups of three to four students.
 Bach group was tasked to choose a minimum of six of the themes and events, which would sign form the basis of their game. How they ordered the locations in the game, how they assigned a theme to a location, and what they chose to write about each, was up to them.

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They were also free to discover and create locations and themes by themselves. A set of 341 documents was made available to the students at the beginning of the scenario. These 342 included a description of the tasks, a list of learning goals, a description of how the 343 scenario was tied to the five basic competencies (a key aspect of the most recent reform of 344 Norwegian education), information on assessment criteria (students were graded on their 345participation including collaboration and end product), a list of resources and internet-346 based sites with relevant historical source material, and a user manual for SILO, the 347 authoring tool for location-based games. A collection of historical sources relevant to 348 the theme, such as magazines and books was made available in the classroom, and the 349students were also encouraged to use local museums, the public library of Bergen, and the 350school library, and also to visit the sites physically. 351

- Game Playing Activity: Each team was to play the game they received, moving around 352
 Bergen and learning about the historical sites in the game. The students were encouraged 353
 to bring cameras with them, or to use the cameras on their private mobile phones, and 354
 record various aspects of the places that they visited so they could use it as source material 355
 for creating a media product after having completed the game. Exactly how they chose to 356
 do this was discretional. 357
- Media Product Development: The media product the students created after playing the game could take the shape of a video or film, a wiki or a blog, or a web page. Based on previous observation of game play, it was decided that the creation of a media product 360 would not interfere too much with the fun aspect of playing of the game, yet at the same time increase the learning potential of the game. As the game application paused automatically when they were at each site, knowing they would have to include the location in their digital media product was intended to increase the attention they paid to the site.

Pedagogical decisions in the learning scenario design

The scenario entailed an adaption of, and intervention into, the normal teaching activity 366 familiar to the students and teacher taking part in the study, with the goal of field-trialling 367 the SILO authoring tool for location-based games in a naturally occurring context. As Holmes 368 and Gee (2016) argue, the Designing Frame on learning is associated with specific challenges 369 that need to be scaffolded, such as use of unfamiliar tools, lack of previous experience with 370 game design for both teachers and students, and most importantly supporting the learning of 371disciplinary or curricular concepts and ideas through the game design process. Before the 372 scenario the teacher and the main researcher planned the learning activities from a student 373 perspective, to ensure that participation was valuable to the students in terms of learning 374outcomes. One of the pedagogical decisions that were made was for the student work in the 375 scenario to be integrated with the national competency framework guiding the school's lesson 376and curriculum design. Grading the students on their work, for example, supported the 377 integration of the scenario into the ordinary school activity, and also helped ensure a commit-378 ment to the participation. The teacher decided how to carry out the student assessment by 379adapting the competency framework for upper secondary school history combined with the 380 five *basic competencies* (written and oral expression, mathematics, reading and digital skills) 381 (Norwegian Ministry of Education and Research 2012) as they are described in the latest 382 educational reform, and made this information explicitly available to the students before the 383 scenario started. (She regularly did this in her teaching.) The teacher decided to grade the 384

students on their collaboration process and the media product created in the final phase of the 385 scenario. 386

Another pedagogical decision touched on student responsibility and trust. As they were to 387 create games for their fellow students, and in that way not only create learning objects for 388 themselves, but also an object for their peers to base their learning experience on. In this way 389 they became *accountable* to their peers in that they needed to create a game that could form the 390 basis of a useful learning experience. 391

The students were put in a position to work creatively with authoring the games. Part of the 392location-based game design was to create a narrative that is a storyline that connected the 393 locations in the game together. Here, they had to rely on their creativity in writing an engaging 394and coherent storyline, and were supported with training in the SILO interface and game 395 design process. In addition, they were also provided a wide range of source material and 396 sources of material to work with, and could freely decide which to use. They were provided a 397 set of historical source material by the teacher, who brought the source material to the 398 classroom, but also pointed to places where they could find more: the public library, the 399school library, museums and the locations that they chose. 400

One of the game design decisions that they were to make, was to decide which 401 locations to use to connect the historical themes to a place. This choice was also 402discretional. The challenge thus became to interpret and extract a set of historical 403knowledge to incorporate in the game, to connect it both with a narrative and place, 404 and additionally to keep in mind that their game was to be played by another group 405and form the part of the basis for that group's learning experience in the scenario. Finally, there 406was an aspect of *competition* involved, incorporated to support student engagement. These 407 pedagogical scenario design decisions on behalf of the teacher and researchers are revisited in 408 the analysis presented below. 409

Analysis - the scenario in practice

The main observations from the different phases in the scenario were that the students 411 displayed several visible signs of being very engaged when creating and playing the games, 412such as whispering while working (to keep their game ideas internal to the group) and working 413during breaks, observations that were confirmed by the teacher in the interviews. She also 414found the classroom conversation to be more task-oriented than usual. To design the games 415and their media products, they also needed to overcome several obstacles requiring practical 416 solutions, to complete their tasks. For example, they spontaneously divided the labour of 417 creating the games by assigning locations to different group members, and then discussed how 418to assemble them into a coherent game afterwards, and sometimes adjusting what they had 419written for a location. They used a wide range of open, online digital tools and sources (e.g. 420Google Street View, Facebook, Moviemaker, national historical archives online, museum 421 websites, etc.) to support both the game design and design of the media products. The student 422 interviews revealed that they experienced the scenario both as a situation of competition, in 423winning the game, but also that they felt responsible for their peers' learning. In the post-424 scenario interviews, one student pointed out that they were "forced" to engage with their peers' 425products, in a way that they didn't have to when for example listening to another group's 426presentation in a different learning scenario. They relied on the gaming experience to create a 427 dependent product. In addition, there was tension between designing a game for another group, 428

which the teacher held forth as the single most motivating factor for the students, and 429 apprehension about what game they would receive from their corresponding group in return. 430

When discussing the integration of the scenario with her everyday teaching practice, the 431teacher highlighted the importance of tying the activities to both competency goals from the 432curriculum and demands for varied assessment methods. She pointed out that much of the 433 required work from her perspective was to translate how the scenario activities were tied to the 434general competency goals, and communicate this to the students, in addition to how they were 435to be assessed on their work. In this respect, she made the point that through 436participation in this learning scenario, she was able to discuss competencies in itself 437 with the students in a new way. This was important as their final exam was organised around the 438 competency goals for each subject, and it was necessary for the students to able to "...work with 439the competency goals, used to hearing about them, and used to using them" (from teacher 440 interview, our translation). 441

When considering the student assessment outcomes she said that they achieved on average 442 the same grades as they had done previously in this class, varying between 6 and 4 (Scale is 6 443 to 0, 6 is best). An unforeseen opportunity related to assessment arose from all the textual 444 documentation that the students produced throughout the scenario (game text in a word 445 processor, game text in SILO, media products), which often mediated the discussion of the 446 students' preliminary work. This was not a main item when planning the scenario, but turned 447 out to offer the teacher new ways of learning about the students work process, which in turn 448offered new opportunities for assessment: 449

"But you got a quite unique insight into students ways of working, I found. That I was
able to learn how they quickly start a discussion and a dialogue. Dividing (the group)450up... Right? For then to go into depth, and then to work together again. And how some
groups are very, where everything is supposed to happen together. So... You get a...
How different students work". (Teacher interview, our translation).450

457 Regarding the aspect of the effects of the scenario on student motivation and engagement, she had discussed this explicitly with the students after completion of the scenario. There were 458 several aspects that had contributed positively to the student engagement; the fact that they 459were assessed and graded, that they were designing and playing games, and the subject matter 460 itself. From her own observation of the students in the scenario she still found the most 461 engaging aspect to be that they were creating something for another group: "(I think it was the 462competition, the assessment and the subject matter that was engaging) ...But another thing, I 463think, was actually that there was another group who were going to play their game? I think 464 that became incredibly important for them.". (Teacher interview, our translation). 465

Overall, the teacher reported that the participation in the scenario made them see the history466in the city in a new way, and attach new meanings and associations to places already familiar467to them. Thus, the learning of history is tied to places and aligned with existing knowledge.468The scenario also provided opportunities for tying together different curricular elements and469goals in one overall learning activity.470

How students organised their interaction in the design process

As previously mentioned, all recorded video was coded into an activity log, and most sections 472 of talk and interaction was transcribed and reviewed iteratively. The goal was to discover key 473

and defining moments in the student's game creation process, in line with Koschmann et al.474(2007) goal of discovering what the students actually were accomplishing, and in line with the475open-natured research question of discovering the educational potential of creating location-476based games.477

Through initial analysis we arrived at a set of themes. They were how designing games for 478 the others – referring concretely to the group of students that will receive their game-features in 479their design process, how the group coordinate their collaborative work, and how the creative 480work of designing a location-based history game involves a series of design decisions. 481 The excerpts are presented using the following structure, from left to right: turn 482number; turn taker: transcript of speech based on Jefferson's (1984) transcript nota-483 tion; and a description of other aspects of the activity where it is relevant. The 484 original language is Norwegian, available in grey text below each translated utterance. The 485 presentation of the analysis is organised around themes that feature in their interaction when 486they are making *decisions* related to their game design process. As such they are candidates for 487 key aspects of designing location-based games. 488

Coordination and articulation work

Excerpt 1 took place in the second session of the game design process, about an hour into the work 490 session. Their interaction concerns how they coordinate their work in the group. They 491 are seated around a table with one computer each, and writing the optional extra hints 492 that will help players who are stuck during game play find the next location in the 493 game. They are working with the list of themes provided for them by their teacher, and have not 494 yet assigned all the themes to a physical location. In a previous exchange they have divided the 495 themes between them. 496

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1	Hanna	Which one should I tie it to then? (3.0) You wrote for number six there? Hviker ska jeg knytte til da? (3.0) Du skrev til number seks der?	Picks up piece of paper with list of themes
2	Simen	(0.7) >No for< (.) >no for< (.) for number three	Looks at the paper
3	Hanna	(1.2) But we have to find out where to place it (1.2) Men vi må finne ut hvor vi skal ha det	Puts down paper

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This excerpt exemplifies how they interactionally coordinate their work, and in the process 502make explicit the kind of work they need to get done in order to finish their task. This kind of 503articulation work (Gerson and Star 1986) is not a process that occurs separate from the content 504of their task as a kind of "meta-collaborative" interaction, but is inextricably tied to the content 505of their work. In Turn 1 when Hanna asks which theme she is to tie the hints that she has 506written to and whether Simen is already writing for theme number six, we see this mix in one 507utterance. It is a question of coordination and of how this ties to the actual decision she has to 508make about how to formulate the text and which location they have decided to have following 509the one she is writing about. In Turn 2, Simen specifies that he is writing for theme number 510three. Hanna then points out that they also need to place their text on a location on a map in 511SILO. 512

Excerpt 1

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Incorporating and presenting subject matter

Excerpt 2 took place in the third session of game design. Hanna and Kaya are sitting next to each other behind two joined desks, and Simen is sitting on a chair that is placed on the opposite side of the desks. They are each using their own laptop. They are discussing how to connect the historical material with the narrative in the game. 517

Ех	cerpt 2		529
1	Hanna:	Is that place to be mentioned in that hint sort of? Skal det stedet nevnes i det hintet på en måte?	
2	Kaya:	(.) I'm writing it like this (.) find the place where the Germans' ships were (inaudible) (.) Jeg skriver sann (.) finn stedet hvor tyskernes skip lå (ikke hørbar tele)	
3	Hanna:	(2.0) Yes (.) But they don't know anything about that (2.0) Ja (.) Men det vet de jo ikke noen ting om	
4	Kaya:	(.) No (.) Nei	
5	Hanna:	(.) But they are going to learn it right? I feel that it is a little (.) Men de skal lære det sant? Jeg føler det blir litt	
6	Kaya:	(.) Is that a little difficult? (.) Er det litt vanskelig?	
7	Hanna:	 (.) Yes, because they have no relation to (.) (inaudible) Yes it is actually possible to imagine of course (.) Ja, for de har ikke noe forhold th(.) (kke nørbar tale) Ja, for så vidt så kan man jo tenke seg til det selvfølgelig 	

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In Turn 1 Hanna asks whether she should include the name of the location about which she 523is writing, and in Turn 2 Kaya replies with giving an example of how she has written the text 524for one of her locations. The theme that she is writing about is the attack on Bergen on April 5259th, 1940, and her choice is that the participants are to search for where the German 526ships were moored. In Turn 3, Hanna points out that the participants won't necessarily 527know where that is, to which Kaya agrees. In Turn 5 Hanna speculates that the 528participants are going to learn that, possibly through playing the game. She begins on 529a sentence where she assesses the difficulty in finding the location by the information 530they have made available. In Turn 6, Kaya finishes her statement by asking whether 531that is too difficult to understand. Hanna agrees that it is difficult, but not impossible 532if they use their imagination. In Turns 3, 5, and 7 in this extract, the pronoun "they" 533is used. The use of they refers to the group that will play the game, and features 534throughout the interaction in this phase of the activity. In particular we see it in 535utterances such as the ones presented here, where it is a mix of envisioning what it 536will be like to actually play the game, and how difficult it will be to find the different points of 537interest, as articulated in Turn 6. This way they are explicitly bringing the other team (as players 538of a game) into their design decisions. 539

Interpreting game mechanics

Excerpt 3 took place during the first session of the scenario. The seating arrangement is the 541 same as described in Excerpt 2. They are discussing the game mechanics as it relates to the first 542 item on the list of themes that the teacher has provided, which they are to transform into a 543

location in their game. More concretely the group is discussing where in the order of the route 544of locations they are to place this particular location. 545

Excerpt 3

- We can't put the number one first (.) because then they will (start on) it straight away 1 Simen:
- 2 Hanna: (1.5) Surely we can have the number one first (.) why not?
- 3 Simen: (0.5) No (.) because then they will receive it straight away (.) they won't even have to (auess) Nei (.) for det at da får de den med en gang (.) de må ikke (gjette) en gang

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In Turn 1, Simen comments that they shouldn't place the top item on the list first, and argues 551that doing so will permit the other team (the group receiving their game) to find this location 552without any effort. Concretely, this location is their own school building, which was requisitioned 553and occupied by Germans during WW2, and Simen is presuming that they will start the game 554play session there. In Turn 2, Hanna responds to this statement by stating the opposite of Simen, 555which is that they can indeed place the school building first, and then asks why not, which 556prompts Simen to explain further. In Turn 3, Simen responds that it would make the other team 557find the location straight away, because of the 30 m circumference around the school, where they 558presumably start the gameplay from. Thus they wouldn't have to search for the location (that they 559will start the game from within the 30 m circumference). His response highlights the central game 560mechanic element that gameplay is about searching for locations based on limited information, 561and that by placing their own school first, they would contradict this aspect of the game in their 562design. This is an important aspect of the game design, and another group used Google Street 563View to study locations closely before deciding on exact location of the POI (to search for natural 564obstacles to the decided game route not visible on maps). 565

Considering and deciding on level of difficulty

The conversation in Excerpt 4 took place in the third session of game design. They are seated 567in the same way as described in Excerpt 2, with the exception that Simen is now facing 90° 568away from Kaya and Hanna. He is observing their conversation (i.e. looking at them, with his 569computer on his lap), without making visible gestures or bids to engage in it. Kaya and Hanna 570are discussing how difficult the game should be to play. In conversation previous to Turn 1, 571they have discussed that they think the game should be challenging enough for the players to 572have to use extra hints in places, but that the game should still be possible to complete by 573making sense of the first or standard hint. 574

Kaya: Yes (.) cou::ld make it (.) But they (1.5) It is not supposed 1 to be like they are not to be able to make it Ja (.) ku::nne klare det. Men de (1.5) Det skal vel ikke 2 Hanna: (.) °This one is very simple (.) If you think like that° Lowers voice, both lean towards the screen 3 Kaya: (0.5) Yes maybe a little simple?

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Excerpt 4

In Turn 1, Kaya agrees that the game should be challenging, but that they should not make the game impossible to complete or too difficult. In Turn 2, Hanna responds by talking about one concrete location in the game, which she finds very simple. She points to the screen, highlighting the game information she is talking about. She lowers her voice considerably. Both lean closer to the screen, and their body language clearly communicates that they are hiding something for their peers, and that the game design and content is a matter of secrecy. In Turn 3 Kaya agrees that the location to which Hanna is referring might be too easy to find.

The whispering, gestures, and poses tied to hiding their game information from their peers 587 illustrated in Excerpt 4, is prevalent in much of the interaction in this phase. Although the 588 whispering is partially a result of the students being placed in the same room as the team they 589 were designing games for, it is clear that they orient themselves toward not revealing what they 590 are doing for the other team. 591

Connecting a theme to a location

In Excerpt 5, the students are discussing how to tie information about one of the themes -593media censorship - to a location in the city centre. They have previously decided on the police 594station, because in 1941 the occupants decided that all privately-owned radios had to be turned 595in to increase their control over public information, and these were to be turned in at the police 596station. Simen and Hanna have been discussing how to provide hint for the game players to 597find the police station, in a way that is challenging. There is a slight pause in their discussion 598before Turn 1. The group's seating arrangement is the same as in Excerpt 4. 599Excerpt 5 600

1	Kaya:	Hehe (0.45) The building where they wear uniforms (1.41) There are of course several places where one does that (.) Hehe (0.45) Bygget der de går med uniform (1.41) Det er jo flere steder man gjør det (.)
2	Hanna:	Y(h)es (0.99) J(h)a (0.99)
3	Kaya:	But it is (0.95) Yes but think a little logically then (0.82) It is Men det er jo det (0.95) Ja men altså tenk litt logisk da (0.82) Det er jo
4	Hanna:	But it is super easy when you (listen) (0.41) Men det er jo kjempeenkelt når man (hører) (0.41)
5	Kaya:	Yes ehrm (10.93) Ja ehh (10.93)
6	Simen:	Yes we'll have to think a little about it Ja altså vi får tenke litt på det

In Turn 1, Kaya in a laughing voice suggests that they provide the hint that the inhabitants 602 of the building in question wear uniforms, as a possible solution to their discussion. She then 603 assesses and modifies her own suggestion somewhat by saying that there are several other 604buildings where uniforms are worn in the town centre, which is something that could cause 605 confusion to the game players. Hanna responds by a mixture of laughing and saying yes, 606 focusing on the joking part of Kaya's utterance. Kaya then requests that they reconsider by 607 insisting that it is a good hint. Hanna responds that it is too easy to understand for the game 608 players. There is then a long pause where they are looking at each other in silence. Finally, 609 Simen breaks the discussion by stating that they have to "think about it", which is an 610 encouragement to reassess the idea put forward by Kaya, and postpone the decision. The 611 group eventually decides to drop the reference to uniforms. Excerpt 5 is an example of how the 612

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group connects a theme to a location, more specifically how they think about providing hints613for finding the location. In this instance a suggestion about hinting to the characteristics of the614inhabitants of a building is discussed, and found to be too obvious or not challenging enough.615We see that the creative process involves communication between the group members, and that616the design process involves both having ideas and making them explicitly available to the617other group members, allowing them to critically assess the suggestions.618

Discussion and conclusions

In the game design phase analysed above, we have reported on an activity where the students 620 are involved in *learning through design*. A key argument in constructionism is that having 621 students engage in design activity can be a fruitful way to support learning (e.g. Papert 1980; 622 Resnick et al. 1988; Resnick 2012). The above analysis has presented a detailed empirical 623 624 account of how the collaborative design of location-based games involves dealing with how to use the authoring tool, game mechanics and connecting each location to a historical event or 625 theme, considering how the game is to be played, and how this involves designing for the 626 activity of someone else and deciding on the level of difficulty. A key observation is that the 627 students in this learning scenario engage creatively with the learning materials and the 628 resources available to them. Their objective was to transform the source materials and concrete 629 locations into points of interest in the location-based game. Further, they relate to the historical 630 materials and sources to create a game and thus have to make design decisions and reflect upon 631 how the game will be received by the other team of students. Such considerations are visible in 632the interaction and a topic of discussion in the group activity. 633

Salen and Zimmerman's (2004) concept of the interplay of challenge and skill, as accounted634for in the literature review, described the inherent challenges of game design. While the635students in our empirical analysis were not trained in game design, they struggle with the636same challenge of providing the players of the game with a coherent and manageable level of637difficulty. Providing the right level of difficulty means finding the balance between making the638game challenging and at the same time possible to complete.639

In this context the students were not only designing a game, but also designing for a history 640 learning experience - a learning experience outside the game itself. Additionally, the intended 641 users were well known peers, visible to them in the classroom, dependent on the game they 642 were to receive for their learning experience, and another group was also going to provide a 643 game in return. The notion of a manageable level of difficulty thus had an additional meaning 644 to the students; that they were somehow responsible for the learning activity, and importantly 645 the subsequent assessment of this activity for their peers, raising issues of trust and account-646 ability. We have illustrated this point through showing how the students explicitly address the 647 notion of designing for someone through the use of "they" in their interaction (excerpts 2, 3 648and 4), and showing how they explicitly discuss what the other students will learn from 649 playing the game they are designing and finding the right level of difficulty for the game-play. 650 In this way, the other team features as putative users of the mobile game in the interaction 651when they are making design decisions. This resonates with Woolgar's classic study 652"Configuring the user" (1992) where he looks at how "along with negotiations over who the 653user might be, comes a set of design (and other) activities which attempt to define and delimit 654the user's possible actions" (p. 61). In our analysis we see an example of how the users are 655 present in the design decisions of the teams, where considerations of how difficult the game 656

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play will be relates to how they define and delimit the users' scope of action. The fact that they657are making a game for fellow students also points to a pedagogical challenge for the students:658They are accountable for making a game that is playable for the other team, and the other team659of students will evaluate them when they play the game.660

The learning scenario presented above, including the pedagogical decisions and general 661 description of the deployment, is meant to address to our first research question in that it 662 illustrates how we can make arrangements that involve collaborative design activities, pro-663 duction of media content, collaborative learning activities, and integrate these with curricular 664 goals and institutional demands. As an example of improving educational practices, we saw 665 the importance of pre-planning with the teacher as a way of aligning with institutional 666 demands and arrangements, for example that the teacher needed to define learning goals for 667 the scenario, and integrate the scenario with assessment criteria, like she also did for her 668 everyday teaching. The learning goals were history specific, but also aligned with the five 669 basic competencies as defined by the Norwegian ministry of education. Revisiting Holmes and 670 Gee's (2015) concept of a designing frame, the design activity involved in this scenario 671required scaffolding in the planning phase. In addition to deciding on issues of defining 672 competencies and assessment criteria, it also involved preparing background literature and 673 game locations beforehand, to limit the amount of possible choices for the students and make 674 the design activity manageable. 675

Regarding Weilenmann et al. (2014), Sharples (2007), and Forte's (2015) discussions on 676015 development of modern media literacy skills, as accounted for in the literature review, the 677 relevance to our study is that the scenario including game design using SILO also is a 678 formative experience with emerging digital tools. For the students taking part in our scenario 679 the game design activities were part of a formal school context where aspects such as 680 assessment and competency development also were important. The teacher dealt with the 681 aspect of assessment and competencies extensively in the planning phase of the 682 scenario, and in her communication with the students. That included deciding and 683 explaining how they would be graded, for example. For the students it became 684 important in that they were creating something that peers were dependent on relatively 685 to how they would be assessed by the teacher. One result of organising the scenario in this way 686 was an increase in the sense of responsibility towards their peers' learning outcome as for 687 example seen in Excerpt 4. 688

One of the goals in our study was to facilitate the development of student engagement with 689 their tasks, and the students showed a high level of engagement with their tasks throughout the 690 scenario, as discussed previously. Part of the student and teacher engagement could have been 691 caused by the novelty effect, it was the first time they used game design as a pedagogical 692 approach in this class. The competitive element of game play was a central part of supporting 693 student engagement. Another aspect of this was that the students worked independently, alone, 694 or as a group with the game design. The teacher interventions were usually about organisation 695of their schedule, clarifications about the task at hand or taking part as a discussion partner 696 with the group in the game design process. We did indeed find, as previously argued, that the 697 students were visibly very engaged over the course of the scenario. The teacher also confirmed 698 this in the post-scenario interview. Organising the scenario in a way that students were 699 dependent on each other was a success in this particular case, but a potential drawback is that 700 it increases the risk of breakdown, and the consequences of a breakdown if students are not 701 motivated. Relying on peers to design a valuable learning experience worked well in the 702 running of this scenario, but if students were to be generally unmotivated, or perhaps driven by 703 destructive competitiveness rather than constructive, the learning activity would have been 704 more vulnerable. 705

Returning to Sengupta-Irving and Enyedy's (2015) finding of how student-driven activity 706 can lead to more strategy talk, we argue that strategizing (in the form of bringing up new ideas 707 when faced with a problem) is taking place in all the excerpts presented in our analysis, and in 708 particular in excerpts 2 to 4. There is a difference in the nature of the student tasks in the study 709 presented here, and the study of Sengupta-Irving and Enyedy, namely that the students in the 710 mathematics study were working to solve defined problems, while the students taking part in 711 this study were working to design or facilitate a learning experience for someone else. 712

A key idea in designing the authoring tool (SILO) is that it should be easy to design 713 location-based games, and the design activity is tied to the construction of a narrative and 714 descriptive text that ties the content to the given location. Some of the intricacies of this 715process include finding interesting physical locations to say something about a theme, 716supporting a suitable sequencing of the POIs, and placing the pin and dealing with the 717 circumference of the POI. The students deal with these aspects in and through their interaction 718 and collaborative activity. More generally the authoring tool is designed to support the process 719of designing location-based games, and the notion of meta-design as discussed by Fischer 720 (2009) as a way to involve end-users in design by "designing for designers" is relevant. In this 721 study we have shown a way to use an authoring tool for location based games to make students 722 designers of games and in this way get them involved in learning through design and being 723 creative participants in what Fischer calls "richer ecologies of participation" and not only as 724passive receivers of texts and other curricular materials. This strategy is also called 725underdesign (Fischer 2009) and involves making tools for content creation rather than 726 ready-made content to be passively consumed, as well as creating technological and pedagog-727 ical conditions for participation in design activities. We see this as a promising way forward to 728support collaborative learning with technology. 729

This paper has described the design, deployment, and evaluation of a learning scenario that 730was focused on exploring the educational potential of location-based games. The scenario 731 through its design and rationale serve as an illustration to how students can learn through the 732 collaborative design and playing of location-based games. This shows the potential of using 733 734 both authoring tools to have students engage creatively with subject matter, and as a focal point of collaborative learning activity. As the topic of the scenario revolved 735 around learning about history, we also found that the ways they relate to this topic 736 when using location-based games offers a new way of integrating curricula in learning 737 activities, and that it is key to think beyond a single subject and look at cross-738 curricular elements and goals in such scenarios. We have also offered a very detailed description 739 and analysis of the practical accomplishment of the learning activities involved in the collab-740 orative design of location-based games. 741

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