It takes three

Re-contextualizing game-based learning among teachers, developers and learners.

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Abstract: *Appropriation of e-learning applications in the class mainly depends on three actors: developers, teachers (experts interested in authoring or using applications), and learners (pupils or students who will play to learn or to express their knowledge). This paper addresses the problems facing primary and secondary school teachers in the technology-enhanced classroom. First we identify three teachers' attitudes towards learning games and apps in the classroom. These attitudes determine how the teacher will contextualize the chosen technologies in the individual (teachers' own appropriation of technologies), interpersonal (interaction and activities in class-guided participation) and community plane (school system and pedagogical goal-apprenticeship). This contribution is based on studies conducted in different Danish schools in the past two years, including primary and secondary education, and classes with special needs students. Our second contribution results from a broad survey of learning applications and game authoring environment for non-programmers, which provided a classification and allowed us to explicit the roles of different actors in the technology-augmented classroom. We adopt an inclusive perspective on the design of e-learning solutions, based on Rogoff three planes of analysis. The insights from our 2 contributions lead to a tripartite architecture for the creation, sharing and managing of learning games, supporting three actors*, and *an early prototype of a CMS, currently under development.*

Keywords: teachers, authoring, technology appropriation.

1. Introduction

This paper addresses the problems facing primary and secondary school teachers as they attempt appropriation of e-learning and games. Successful appropriation and integration of game-based and e-learning tools in the class depends on 3 main actors: developer, teacher and learner.

Developers can be researchers or commercial entities, and from our broad applications survey and studies in schools of various level, we know that they have little control over the actual adoption, deployment and contextualization of their products.

In this paper we focus on the teachers, looking at the challenges they face in the attempt to integrate e-learning games and other learning media in their daily practice. The digitisation of learning practice has complex implications for learning and teaching practice with respect to: planning of teaching activities, pupils' expectations, and social interaction in the classroom, as discussed in Hanghøj (2013) and Marklund and Taylor (2015). Available e-learning media might range from games (especially free-to-play), web-sites, mobile apps, as well as actual e-learning applications. Often it is the institution that decides which platform to adopt, and that adds to the external pressure when integrating e-learning in teachers' practice.

Learners are the third actor in this scenario and they are typically the users and players of the e-learning applications and games, hence, end-users for developers. Because of this, following modern development methods (such as agile methods and user-centered design inspired methodologies) we see a risk of focusing on learners and considering experts and practitioners (like teachers) as less central to research projects and commercial products. A lot of attention has been dedicated to how learners at different age relate to the use of digital learning media, emphasizing for instance how digital e-learning media promote playful forms of learning, elicit motivation, and enrich social interaction in the classroom (Annetta, 2008). However, many researchers report cases of testing of e-learning media in which teachers have not been involved, such as in (Madsen et al, 2008).

In the next section (2) we present related work and the theoretical framework of this study, section 3 discusses our data about the different attitudes of primary and secondary teachers towards e-learning games and

media. Section 4 discusses our data about the survey we have conducted on existing digital applications targeted at e-learning, with respect to the roles played by the 3 actors. In section 5 we discuss our findings and introduce our concept of a tripartite platform to support teachers in their practice.

2. Related work and theoretical background

The Danish school system has become increasingly concerned of global trends, in adopting new technologies and teaching methods[1], which implies an additional pressure on the individual teachers. Through our research we have entered in a dialogue with teachers from different local schools about their perspectives on the use of new learning technologies, the needs of their pupils and theirs, and we found that teachers' expectation and attitudes towards learning technologies can determine how meaningfully are these technologies integrated in the classroom. Therefore, we argue that teachers' attitude towards learning technologies is an important sociocultural factor to consider in the design and evaluation of new technologies for e-learning.

Our analysis is grounded on the work of Rogoff (2015), according to whom learning takes place within communities comprising adults and children engaged in shared activities. Being contextualized within a community learning is a sociocultural activity that can be analyzed through three different planes: community/institutional, interpersonal and individual planes (Rogoff, 1995). These planes correspond to three processes that are named apprenticeship, guided participation and participatory appropriation.

The process of apprenticeship corresponds to the community/institutional plane and deals with how learning takes place in different societies in relation to practices and institutions of the community in which it occurs. This plane of analysis focuses, therefore, on how learning processes are integrated in society, its norms, values and traditions.

The interpersonal plane corresponds to the process of guided participation, which deals with the modalities in which learners and teachers participate in learning processes. Guided participation is seen by Rogoff as all the set of modalities through which teachers facilitate learning, including eventual practical tasks, lectures or other in person or remote forms of interaction. According to Rogoff a precondition for learning is that the learners make active use of social guidance, which means that the learners are supposed to freely engage in a dialogue with their teachers.

The third personal plane corresponds to the process of participatory appropriation, through which learners "change" and become prepared to contribute to future related activities. In this respect learning is not a mere acquisition of knowledge but a process of transformation, through which individuals become fully functioning adults in their community. We find that this perspective can be applied to the analysis of the digitalization of learning practices enabling us to uncover needs and challenges from the side of both learners and teachers.

Our study provides addition to the studies conducted by Marklund and Taylor (2015) who have investigated the lack of integration of games within education in relation to the many roles that teachers have to take on in order to integrate games in their class. According to the two authors, games have been discussed as offering great potential to innovate learning practice for their educational and experiential value (Annetta, 2008). However, Marklund and Taylor have found that despite teachers' positive attitude towards the use of games, there is a lack of integration of games within education because games are "laborious and resource intensive to use" and there are "few standards to guide educators through the complex process of integrating games into their working environments" (Marklund and Taylor, 2015). Furthermore, these two authors have contributed to the understanding of the roles that teacher have to play, in order to meaningfully introduce games within the constraints imposed by the curriculum, the uncertainty of the reliability of the hardware and management of the tools. Hence, teachers find themselves acting as gaming "tutor" as they proceed at "guiding their pupils" during gaming sessions also securing that the session runs "reliably on an administrative perspective" (Marklund and Taylor, 2015 p. 363). Teachers also act as "authority and enforcer of educational modes of play", in order to support "productive collaborations" among more and less proficient players (Marklund and Taylor, 2015 p. 364). Finally, teachers have to act as "subject matter anchor" and bridge "the gap between the game content and the details of the subject matter the game is intended to teach" (Marklund and Taylor, 2015 p. 365). The demand for teachers to play all these roles in the orchestration of games-based learning, makes the integration of games in learning hard and time consuming.

In Hanghøj (2013) the term Game-Based Teaching is introduced to emphasize the need of discussing game-based learning from the perspective of teachers. Hanghøj considers the complexity of adopting games in the

[1] Danish article *"We are the last country in Europe that has taken the digitization us"* https://www.folkeskolen.dk/579902/vi-er-det-sidste-land-i-europa-der-har-taget-digitaliseringen-til-os

classroom by asking questions like “what roles should teachers assume when they facilitate educational games?”. In the next section we analyze teachers in a similar way, only instead of focusing on their roles in the classroom we are interested in how the individual teacher relates to technology. Our efforts towards empowering teachers to become creator of contents, and improve the dialogue between developers and teachers (that we discuss in section 5), can be considered a direct consequence of the future work in Hanghøj (2013).

3. Teachers' attitudes

Our first contribution is the identification of three teachers' attitudes towards learning games and apps in the classroom. These attitudes determine how the teacher will contextualize the chosen technologies in the individual (teachers' own appropriation of technologies), interpersonal (interaction and activities in class-guided participation) and community plane (school system and pedagogical goal-apprenticeship). This contribution is based on studies conducted in different Danish schools in the past two years, including primary and secondary education, and classes with special needs students (see table 1, where teachers are referred by their initials).

TABLE 1

#	school	Grade	teacher/subject	activity and time	observer
1	Holluf Pile Skole (Odense)	4th grade primary school	L. - English	a class learning English - fall 2014	Andrea
2	Agedrup Skole (Odense)	4th grade primary school	S. N. - English	a class learning English with IT support - fall 2014	Andrea
3	Højmeskolen (Odense)	8th grade primary school	H. S. - English	dyslexic class learning English with IT support - fall 2014	Andrea
4	Aadal Skole (Esbjerg)	primary school pupils of various grades	B. - History, Vikings	ASD children learning history via MicroCulture - spring 2012	Emanuela
5	Nyborg gymnasium (Nyborg)	1st year	C. - Latin	visible learning project - fall 2015	Emanuela
6	Nyborg gymnasium (Nyborg)	1st year	H. - English literature	visible learning project - fall 2015	Emanuela
7	Nyborg gymnasium (Nyborg)	2nd year - international programme	S. - English literature	visible learning project - fall 2015	Emanuela

Our data were gained through the application of interaction analysis (Jordan and Henderson 2007) and visual ethnography (Pink 2006), during in situ observations and when possible on video recordings afterwards. In our studies we paid particular attention to how the teachers explained their individual strategies in integrating digital technologies within traditional teaching practices and tools, and their desire for choosing existing tools or activities and/or to create their own.

3.1. Cases

In this section we discuss in details our different case studies and our findings about the individual teacher’s attitude towards e-learning and use of technologies in their class.

Case 1: H. teaches English in the Holluf Pile primary school. Together with some undergraduate students from the Southern Denmark University we observed some of his classes with 4th graders, whose goal is to build a basic English vocabulary, practice pronouncing and recognizing English words, so conversation is a typical part of their classes. In one of our visits H. gave the pupils a script of a conversation among a group of customers and a waiter at a restaurant, and each group of pupils was asked to assign themselves roles, then read aloud the script. The groups spread out and rehearsed, then the teacher went around to listen to each group and correct the pronunciation. One of us followed 1 group of 3 girls who play-acted the script, taking the exercise very seriously, and even corrected each other’s pronunciation. At the time of their third play-acting, the group was having difficulties keeping focus. The main problem expressed by H. was the lack of support to remember the performance and feedback of the different groups. We discussed the possibility of using mobile apps to record the pupils and his feedback, to keep better and more permanent record without technology breaking the flow (Marchetti and Valente 2016 a).

Case 2: S. N. teaches English at the Agedrup Skole. During our observations he was with 4th graders in the school's IT room, where pupils can work on stationary PCs and access the web. S. N. explains that the school also bought *chromebooks*[2] that individual pupils can borrow for 3 weeks at the time. When the class is at the IT room pupils work individually at their PCs, and each desk accommodates 2 so they often chat while navigating the web. S. N. gives them a choice between using a comic book editing website (to practice English by creating custom comics) and reading/listening to online English audiobooks. S. N. told us that his pupils often discuss critically games and mobile apps, so that any custom made e-learning tool for English will have to be very good to stand up to their high expectations. We could also see that S. N. is very comfortable finding and adapting existing applications and materials to suit his teaching needs. He likes to use existing websites, possibly free, but would be particularly interested in better support for peer-learning, as his main concern is to keep his pupils focused and help them go deeper.

Case 3: H. S. is an English teacher at the Højmeskolen, and she works with a class of twenty 8th graders, between 14 and 15 years old, all with various degrees of dyslexia. In our visits, H.S. had a laptop for presenting the daily topics, but clearly her focus was on direct interaction among her pupils. H. S. follows an immersive approach, so everybody speaks mostly English in her classes. On one occasion she organized a game where each pupil would get a card with questions about a text that was previously read in class, then all pupils will stand at the center of the classroom (the desks were arranged to form a U, creating a stage-like space at the center) and worked in pairs reading and answering the questions to each other. Once 2 pupils finished their chat, both moved away to form new pairs, and the exercise was repeated. This task continued for 10 to 15 minutes, while H. S. mingled with her pupils interacting with them. H. S. is good at taking advantage on various communication modalities in her teaching to accommodate the needs of her dyslexic pupils; meanwhile, her laptop was so rarely used that it kept going into blank screen. Later in her meeting room, H. S. discusses of the problems with IT and the fact that she regards engaging her pupils as her main goal; she describes IT as a complication since often she has to spend too much time helping pupils with the dictionary or some word processor. She describes herself as "not an IT expert".

Case 4: B. is a primary school teacher at the Aadal Skole, who is working with classes of children affected by autism spectrum disorder (Marchetti and Valente, 2016 b). In her job she faces a particular challenge, as she has to encourage her pupils to develop their social and linguistic skills, while at the same time teaching them subjects from their curriculum. According to B. her pupils have difficulties in grasping abstract knowledge in their different subjects, because of their challenges with communication and imagination. Therefore, B. is adopting what she calls "hands-on methods", arranging workshops in which her pupils have for instance to make Viking Age houses with turf and wood to talk about history, walk in the woods to talk about natural sciences (Marchetti and Valente, 2016 b), or use computer applications and games. According to B. the children are happy to play on the computer as they can avoid the uneasiness of social play. Therefore, B. does not seem to perceive digital technologies in a different way from traditional educational material, however, her main challenge is to find digital media that are meaningful to her subject and the educational activities she organizes.

During a cooperation with Nyborg gymnasium we observed a Latin teacher (C.) and two English teachers (S. and H.), who have shown great interest for using more digital applications in their classes. In general they adopt a *flipped classroom* approach (Howard, 2015), in which the students have to take the responsibility of looking at new subjects on their own and do their assignments in class.

Case 5: C. has tried different methods to make her subject "alive" for her students, including theatrical staging of Latin comedies. C. also creates forms for students' self-evaluation on her laptop, which are normally printed out, but she said during our study that interactive applications would support better longitudinal evaluation, as "a paper form can be used only once and then it is thrown away."

Case 6: H.'s students are required to read a series of English novels and write essays. During our observations H. was active in using the equipment provided by the school, including a smartboard and a projector for each classroom, and a laptop for each teacher. She also prepares forms on her laptop, which are printed out and given to the students to support critical shared discussions. She also uses the projector to watch with her class the cinematic adaptation of the read novels.

Case 7: Finally S., who is originally American and also teaches English, engages his students in production of texts, multimedia and oral presentations, in group and individually. During our observations the students were writing posts on street art in Dublin just after a school trip on their WordPress individual blogs. According to S. the students perceive writing blogs as a "cool" activity, as they are already aware of the blogosphere and follow specific writers, at the same time enabling them to develop professional IT competences.

[2] Official Google website for chromebooks in Denmark: http://www.google.dk/chromebook/

3.2. Three attitudes

Based on our studies we found that different teachers had different attitudes in the way they relate to digital learning technologies, which we call:

- **Designers of (digital) contents.** Teachers, who have new ideas about how to engage their students in learning activities and have high demands for e-learning approaches.
- **Mediators.** Teachers who look at technologies as a valuable tool and see themselves as mediators between the learning subject and the tools they choose to use in class.
- **IT-concerned.** Teachers who see IT as something extra to learn, something besides their subject-related skills, and potentially time-consuming when not reliable.

These attitudes emerged from our analysis of the conversations we had with the teachers and observations of their behavior during field study and testing of technologies. The teachers we observed were showing a combination of these different attitudes depending on the specific technologies and the activities at hand.
We can see that some teachers have a positive attitude towards the use of available digital technologies, as it is also claimed by Marklund and Taylor (2015), but have expressed the desire to be more in control of the available applications. This case is represented by teachers, who have new ideas about how to engage their students in learning activities and are not easily satisfied with taking what is around them, even though they see a value in e-learning approaches. As a result these teachers constantly create and try out new approaches to foster students' engagement with the subject. We also found that *designers of contents* are challenged by the difficulty of altering digital media, as these require skills in programming and visual or game design that they do not have. In such cases the teachers might design new content digitally (e.g. an electronic text), however the final product is often low-tech (such as a hardcopy) because of the difficulty in generating digital interactive content; teachers compensate for this problem with role play and social interactions.
Some teachers are instead positive towards digital technologies but see themselves as using existing, often non-educational applications that might seem relevant to their subject. In this respect these teachers act as mediators between the learning subject and the media they choose for their class. These teachers express creativity in the way they reinterpret digital media from the community to their personal plane and then reintroduce these media in a new original way within their interpersonal plane of interaction with their class.
IT-concerned teachers appear interested in the potential offered by e-learning applications, especially when they are directed towards their students and do not involve picking up too many new expertises from their part; teachers seem to prefer traditional media and learning experience. This makes sense considering that many teachers can usually deal with digital texts and perhaps video editing, but very few have been taught web-development or programming.

4. Survey of learning games and applications

Our second contribution results from a broad survey of learning applications and game authoring environments for non-programmers, which provided a classification and forced us to reconsider the roles of different actors in e-learning. Table 2 shows a significant selection of the games and applications that we analyzed in the past 2 years. The categories (see the *group* column) are:

1. Game-based learning about programming for children and novices
2. Learn programming by coding games. 2B is the category for authoring tools to create games with some programming, and 2C is for programming courses
3. Educational games to learn math
4. Applications and games for language learning, in particular learning basic Japanese
5. Websites to learn about programming and IT without coding for children

The first category includes games that teach or provide an understanding of basic programming. The learners are children who can learn by solving puzzles or progressing through the levels. The developers are in charge of designing the levels and they have sole control on the content. Teachers might adopt these games as part of their teaching materials as tasks for their pupils or students, but have little freedom in customizing the

contents of these games and applications; an interesting exception is lightbot version 2 which supports creation of custom levels.

Applications in category 2 focus on having novices coding (parts of) games, leveraging on game development to boost motivation. Greenfoot for example helps learn Java programming by easing development of 2D games. In (Kölling, 2010), the design goals behind Greenfoot are summarized as: "From the student's perspective, the goal is to make programming engaging, creative and satisfying. […] From the teacher's perspective, the goal is for the environment to actively help in teaching important, universal programming concepts.". We find that teachers in computer sciences are in a special situation with respect to appropriation of IT in the classroom, compared to other teachers: they are to a certain degree both developers and domain-experts. However, even with their privileged relation with IT, Kölling stresses the need to support secondary school computer science teachers, who "often do not have much time for the development of material or for off-site professional development and training. Thus, we need infrastructure to support the system that provides explicit support for teachers, such as discussion and sharing of teaching material." (Kölling, 2010).

Table 2

name	link	group	platform
lightbot	https://lightbot.com/	1	web
Lightbot : Code Hour	https://play.google.com/store/apps/details?id=com.lightbot.lightbothoc	1	android
Turtle Draw	https://play.google.com/store/apps/details?id=com.alimuzaffar.turtledraw	1	android
greenfoot	http://www.greenfoot.org/door	2	Windows/Mac
Pocket Code	https://play.google.com/store/apps/details?id=org.catrobat.catroid	2	android
Scratch	https://scratch.mit.edu/	2	Windows/Mac
Squeak/Smalltalk	http://squeak.org/	2	Windows/Mac
8-Bit RPG Creator	https://play.google.com/store/apps/details?id=com.scottgames.rpgcreator	2B	android
Game Creator Demo	https://play.google.com/store/apps/details?id=org.silentworks.gamecreatorplayer	2B	android
Generative Music Generator	https://play.google.com/store/apps/details?id=com.intermorphic.mtfrgp	2B	android
Make Action PicoPicoMaker WIDE	https://play.google.com/store/apps/details?id=air.jp.globalgear.picow	2B	android
Javascript course (Code Academy)	https://www.codecademy.com/learn/javascript	2C	web
Divide By Sheep	https://play.google.com/store/apps/details?id=air.com.tinybuildgames.sheep&hl=en	3	android
Fractions & Smart Pirates Free	https://play.google.com/store/apps/details?id=ru.vspaces.fractionsFree	3	android
Fractions Lite	https://play.google.com/store/apps/details?id=com.infinut.kidsfractions.lite	3	android
Regneregler	https://play.google.com/store/apps/details?id=dk.regneregler	3	android
Rekenrek by mathies	ca.mathclips.clips.rekenrek	3	android
Japanese Hiragana Handwriting	https://play.google.com/store/apps/details?id=com.teachersparadise.japanesealphabethiraganahandwriting	4	android
Kaite Oboeru: Dora-Gana	http://gamewise.co/games/20032/Kaite-Oboeru-Dora-Gana/Walkthrough	4	NDS 2008
Learn Japanese Phrasebook	https://play.google.com/store/apps/details?id=com.nugalis.japanesephrasebook	4	android
Memrise	https://play.google.com/store/apps/details?id=com.memrise.android.memrisecompanion	4	android
CS unplugged	http://csunplugged.org/	5	web/offline
Hello Ruby	http://www.helloruby.com/play	5	web/offline

The applications in sub-category 2B include authoring tools targeting children's digital creativity, level design more than programming. We find interesting that these tools are freely available online, but they are consistently missing from teachers IT toolboxes. The sub-category 2C includes high-quality websites supporting

self-learning, automatic assessment and progress tracking of young adults or even professionals in learning a specific programming language from the ground up. Since these products are created by developers with the learner in mind, they typically leave no room for customization by the part of teachers.
Applications in category 3 are educational games, and also in this case the developers address directly the learners. We find that successful games in this category have good graphics, smooth difficulty progression, and the best ones offer the player/learner multiple representations of the same concepts. Explanations of how operations should be performed (as in the case of fractions) or how concepts should be understood are usually missing, or presented outside gameplay.
Applications for language learning are found in category 4. Among those we have analyzed and tested Memrise's basic Japanese course for 1 semester. The Memrise mobile app has an interesting and rather typical structure: the content is organized in courses made of lessons, each consisting of a sequence of activities in the form of short, game-like applications. Every activity in Memrise is logged and gives points, so that the overall score keeps incrementing and an automatic calculation assesses the level reached by the learner. As in many of the applications we analyzed, the materials in the Memrise lessons are defined by the developers and cannot be changed. Moreover, the sequence of mini-apps involved in each lesson is predefined: there is no explicit room for the teacher-role in the app.
Our final category includes websites enabling children to learn about programming and IT without actual coding, but through physical activities, tinkering and low-fidelity prototyping. In this way site developers assume the presence of teachers, and in some cases also encourage teachers to share new materials through the website.
Summarizing, we can arrange all applications and games into 3 groups, with respect to their main goal:

- **Training**, based on repetition/exercise, provide little feedback, require previous knowledge by the learner.
- **Assessment**, provide support for self-testing, good for learning nomenclature, facts, dates.
- **Epistemological**, allow for procedural and ontological knowledge acquisition, support learning of new categories, provide feedback on the mental model not simply on the errors.

In this respect we find a large inventory of tools, among which only a few address or simply consider the presence of teachers.

5. Discussion and conclusion

We adopted an inclusive perspective on the design of e-learning solutions, based on Rogoff three planes of analysis (Rogoff, 1995). We look at the making of e-learning media from the personal and interpersonal planes, which deal with how individual teachers and learners participate in learning processes, respectively appropriating knowledge and the use of tools, to learn or enable others to learn arranging resources for guided participation. From the community plane we consider learning practices as a form of apprenticeship contextualized within the Danish school system, its global challenges, and the role of developers in creating new tools that should support learning intended as a practice, in which learners engage together with their teachers to become active citizens.
Combining our two contributions, we propose a scenario that generalizes on Memrise-like apps. A single app (or webservice) similar to a CMS, that contains materials and mini-apps, where teachers login and compose a course by (1) creating a sequence of lessons, (2) adding mini-apps to each lesson, (3) specifying contents for each mini-app in each lesson (an activity similar to level-design in digital games). The learner then creates a personal copy of a lesson in a course, and learns by going through the mini-apps. The progress is kept in her copy of the lesson and of the mini-apps, to be used as documentation of her work, to discuss with peers or a teacher, or to submit partial solutions to her teacher when stuck. Developers are involved in the creation and maintenance of the CMS, and in the creation of the mini-application modules. In our early prototype, mini-apps are in fact small sandbox games, since we believe sandbox games can work as a visual domain-specific languages (Fowler, 2010; Wienands and Golm, 2009) and support teachers' authoring. Moreover, teachers can request new or variations of the mini-apps to better express the tasks they want to assign the students. Finally, experts often need automatic (or at least assisted) generation of exercises: we are currently running interviews based on low-fidelity prototypes, to address this problem.

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