Implementation of a Framework for e-Assessment on Students' Devices

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Abstract: Following the trend of digitalization in university education, lectures and accompanying exercises and tutorials incorporate more and more digital components. These digital components spread from the usage of computers and tablets in tutorials to incorporating online learning management systems into the lectures. Despite e-Assessment being a valuable component in form of self-tests and formative assessment, the trend of digitalization has not yet been transferred on examinations. That is among other things caused by financial reasons, because maintaining a suitable IT-infrastructure for e-Assessment is expensive in terms of money as well as administrative effort. This paper presents a Bring Your Own Device approach to e-Assessment as potential solution to this issue.

1 RESEARCH PROBLEM

1.1 Introduction

Following the general trend of digitalization, university teaching at German universities incorporates increasingly digital elements, for example a learning management system (LMS) or mobile apps (Politze et al., 2016). The incorporation of digital elements at this point is not limited to lectures, but also tutorials keep up with this trend. It is, for example, rather common by this time, that computer science students use their own devices during tutorials. Examinations, however, are not part of this development in a similar manner (Hochschulforum Digitalisierung, 2016)(Themengruppe 'Innovationen in Lern- und Prüfungsszenarien', 2015)(Deutsch et al., 2012). Similar trends can be observed also in other countries like the United Kingdom (Walker and Handley, 2016), Greece (Terzis and Economides, 2011), the United States of America (Luecht and Sireci, 2011) or Australia (Birch and Burnett, 2009). Due to the slow progression of integrating e-Assessment into higher education, there is a media disruption between the particular elements of a study course. Figure 1 illustrates this situation. Retaining examinations on paper is often caused by reservations against e-Assessment. These reservation concern for example the fairness or reliability of digital examination systems (Vogt and Schneider, 2009). Especially the students have to accept e-Assessments in order to successfully introduce those to higher education (Fluck et al., 2009)(Terzis and Economides, 2011). There are, however, likewise significant benefits, which makes e-Assessment worth considering, especially in computer science education. (see Section 1.2).

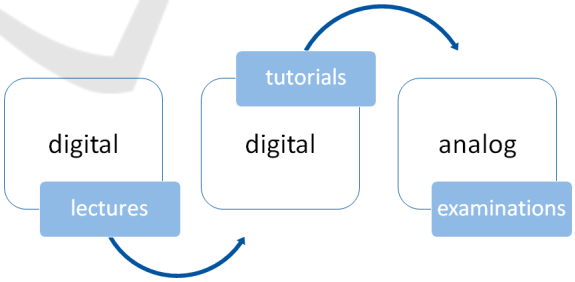

Figure 1: Actual state of the digitalization in university courses.

Beyond reservations against e-Assessment, also financial reasons interfere with the introduction of e-Assessment, because maintaining a centrally managed IT infrastructure for digital examinations is costly in terms of money as well as administrative effort. The latter is reported by several universities, which have such an infrastructure, for example the University of Duisburg-Essen (Biella et al., 2009) and the University of Bremen (Bücking,

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2010). Since most students possess already devices that are suitable for e-Assessment (Dahlstrom et al., 2015)(Poll, 2015)(Willige, 2016), Bring Your Own Device (BYOD) is a potential solution to overcome this issue. This paper presents an approach to the development of a software framework that enables institutes of higher education to introduce e-Assessment on the basis of BYOD.

1.2 e-Assessment in Computer Science

Utilizing BYOD to create an affordable setting could crucially boost the usage of e-Assessments, which do not only overcome a media disruption between lectures, tutorials and the examination, but can offer a lot more of advantages. Especially in the field of computer science the implementation of (summative) e-Assessments for certification would greatly benefit examinations in various aspects. First and foremost, e-Assessments bring the main subject of study, namely the computer, into the examination, but there are also other facets, which improve the setting of the examinations for both, students and lecturers.

1.2.1 Usage of Domain-specific Tools

Often, tutorials are held in addition to the lectures to provide hands-on experience besides theoretical education. These tutorials introduce domain specific tools to the students. In a programming course the students normally get used to integrated development environments, e.g. Eclipse [1] or NetBeans [2], during the tutorials, but are currently most often asked to write the examinations on paper. Therefore, these tools can also be used in the examinations, closing the previously described gap between tutorial and examination.

1.2.2 Simplified Correction

The same tools that the students can use throughout the examinations, are also available to be used by the correctors, reducing the effort for correction considerably (Jara and Molina Madrid, 2015)(Vogt and Schneider, 2009). Parts of the examination can even be corrected semi-automatically. In programming courses, for example, a set of unit tests can be used to determine whether a student's code fulfills all the requirements demanded by the examination. Only if some of these tests fail, the corrector has to have a deeper look into the student's exam. Additionally, also the effort for correcting the other parts of the examination is lowered, because the readability is clearly improved in comparison to handwritten examinations.

[1] http://www.eclipse.org
[2] http://netbeans.org

1.2.3 Improved Level of Assessment

By providing domain-specific tools, the proficiency level of the examinations can be increased remarkably. Considering Krathwohl's revised version of Bloom's Taxonomy of Educational Objectives (Krathwohl, 2002) (see Fig. 2), assessing the more complex levels of the taxonomy, like Evaluate and Create, can be achieved in a more realistic fashion, because the domain-specific tools can take care of the lower levels of the taxonomy, so that the students can focus on the higher levels. In programming courses, the integrated development environment for example provides auto completion, therefore the students do not need to remember every keyword of a programming language.

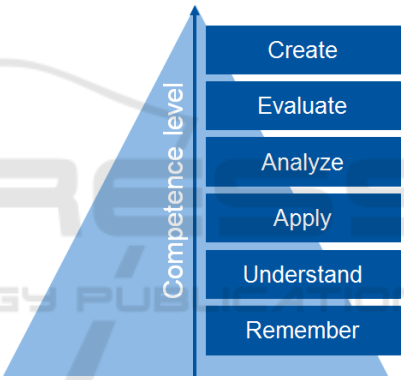

Figure 2: Revised Taxonomy of Educational Objectives by Krathwohl.

1.2.4 Innovative Methods of Examination

With the implementation of e-Assessments, innovations in the methods of examination become possible (Themengruppe 'Innovationen in Lern- und Prüfungsszenarien', 2015)(Winkley, 2010). In programming courses, for example, modern methods like test driven development (Beck, 2015) can be assessed, which is not possible with an analogous examination.

1.3 Basic Conditions

During an examination, students have to be treated equally. This is an ethical guideline, which examiners should obey. Besides being ethically important, this principle can be required by law, depending on a country's particular law. In Germany, for example, Article 3 of the Basic Law for the Federal Republic of

Germany enforces an equality of treatment for all people ('Equality before the law') (German Bundestag, 2012). Since the students' devices are, in the worst case, all different from each other, it is practically impossible to provide every student with the exact same conditions than every other student. This is an issue that has to be taken into account when designing the e-Assessment framework.

1.4 Wording

For the ease of readability, the rest of this paper will stick to the following wording:

- **e-Assessment Framework.** The unity of all pieces of software that are developed throughout the PhD project.
- **e-Assessment Application.** The software that runs on the students' devices and is used by them to work on the examination.
- **Lockdown Application.** The software that runs beside the *e-Assessment Application* and prevents the students from cheating.

2 OUTLINE OF OBJECTIVES

2.1 Equality of Treatment

As described in section 1.3, all students have to be treated equally during an examination. Since the students' devices are beyond control of the examiners, the design of the e-Assessment framework has to tackle this issue. Therefore it was concluded, that a certain level of features regarding processing power and memory capacity on the students' devices has to be required. The e-Assessment application has then to be designed in a way that students whose equipment is beyond these requirements do not have an advantage over the students whose devices fulfill the requirements only just. Beyond the different hardware specifications of the students' devices, also the potentially different operating systems have to be taken into account. The e-Assessment application should be platform independent, so that no group of students has a disadvantage, because they have a not-supported operating system installed on their devices. Thereof the first research objective can be concluded:

Research Objective 1: How has a software framework that fulfills the previously described requirements to be designed?

2.2 Reliability

In order to successfully introduce e-Assessment, reliability is one of the key elements that have to be present, as pointed out by Dahinden (Dahinden, 2014). Reliability in this context refers to two different things. First, the hardware infrastructure itself has to be reliable. Second, also the data that is processed has to be reliable. The latter includes saving the data securely during and beyond the examination. Safety has to be ensured regarding hardware errors and human manipulation of the data. These requirements hold obviously also when doing BYOD. Once the examination is over, there is no difference between a 'regular' and a BYOD e-Assessment. During the examination, however, there is a difference, because the reliability of the data has to be ensured although the data is created on a computer, which is not per se under full control of the examiner ('untrusted platform'). Hence, the second research objective can be concluded:

Research Objective 2: Can the system proposed by Dahinden be used in a BYOD setting? If not, what changes have to be made in order to ensure reliability in a BYOD context?

2.3 Lockdown

Since e-Assessments in a BYOD setting are carried out on the students' devices, precautions against cheating have to be taken. Otherwise, students would have the possibility to prepare their devices before the exam to provide themselves with illegal advantages. Therefore a so-called lockdown application can be used. This is an application, which prevents the students from unauthorized actions during the examinations. These actions include especially starting prohibited programs and accessing illegal information, e.g. on the devices' hard drives or on the internet. At this point the potentially different operating systems on the students' devices have to be taken into account, since each of these operating systems possibly offers different ways of cheating to the students so that also different countermeasures have to be implemented. However, there are also doubts about the general security of lockdown applications, for example Safe Exam Browser[3](Søgaard, 2016). This leads to the third research objective:

Research Objective 3: Is a lockdown application a generally secure approach? If yes, can a lockdown

[3]http://safeexambrowser.org

application be implemented platform independent? If not, are there other ways of ensuring security?

2.4 Advanced Security

The previously described lockdown application can only reliably prevent cheating if it deployed and used on the students' devices as intended. If, however, the students would find a way to circumvent the lockdown application or to modify the deployed executable, the integrity of the examination could not longer be ensured. An easy way to render the lockdown application useless would be, for example, to start the lockdown application and the e-Assessment application in a virtual machine, therefore having access to the unsecured host system during the examination. Therefore another security-related research objective can be concluded:

Research Objective 4: Which additional security measures have to be implemented, in order to ensure that the previously described lockdown application works as intended?

2.5 Acceptance

An e-Assessment framework or, more general, e-Assessment as a whole has to be accepted by both, teachers and students, in order of being successfully introduced at an institute of higher education. Therefore it is very important to measure the acceptance of the e-Assessment framework, once it was implemented. Hence the last research objective can be concluded:

Research Objective 5: Is an e-Assessment framework, which is designed and implemented in accordance with the previously described research objectives, accepted throughout teachers and students? If not, why?

3 STATE OF THE ART

The following sections described the state of the art of key aspects of the previously described research objectives.

3.1 Bring Your Own Device

Bring your own device itself is not a new phenomenon and is already used in context of higher education around the globe (Küppers and Schroeder, 2016). The approaches in use cover a lot of different scenarios. The differences between these scenarios result from two main questions:

1. Which software is used on the students' devices?
2. How are the students' devices connected?

The following paragraphs describe briefly, the key facts for both questions.

Software. The students' devices can either be used as a workstation or as a thin client. In the first case, fully functional software is utilized on the students' devices, using the processing power of the these devices. That software can be for example a programming IDE, a CAD program or a simple web browser for accessing a LMS or the like. This scenario can be further subdivided, since it is possible to use the operating system that is already present on the devices or to provide the students with a pre-configured operating system (mostly linux distributions), which the students have to boot on their devices, for example from a USB-stick. In difference to that, the students' devices can be used as thin client, i.e. with a software that connects to a virtual desktop infrastructure (VDI). In that case, the server provides the processing capacities and the students' devices only serve as an interface to the server.

Connections. Depending on the software scenario, that is used, there are different possibilities for the students' devices how these are connected to a network. If no online resources are needed throughout the examination, the devices can be not connected at all. Once online resources are needed, for example the connection to a LMS, not being connected is obviously no longer an option. In that case there can either be a special, secure network for the examination or not. If, for example, the standard WiFi network of a university is used to provide connectivity throughout the examination, the software on the students' devices would have to ensure that no illegal online resources are accessed.

All of the approaches described in the cited review paper, however, are either not platform independent or not technically secured in a sound way. Especially the latter causes a lot of effort for the invigilation during the examinations. Additionally, it is pointed out that backup devices have to be held by the invigilators. These are going to be used if one student's device breaks down during the examination.

3.2 Cross-platform e-Assessment

LMS are potentially cross-platform e-Assessment applications, since they allow for quizzes or the like. Examples are Moodle[4] or ILIAS[5]. Since these LMS are accessible via a web browser, every platform for which a web browser is available can be used for e-Assessment in that context. The regular LMS, however, have only a very limited set of available types of assignments (Eilers, 2006), for example multiple choice questions. Therefore, specialized types of assignments have to be implemented as a plugin in order to make use of those in an examination. This was, for example, done in (Amelung et al., 2006) and (Ramos et al., 2013).

In addition to LMS, which lack features particular to a certain subject, there a specialized learning management systems (SLMS) (Rößling et al., 2008). Examples are (Amelung et al., 2011) for computer science and (Gruttmann et al., 2008) for mathematics. These cover a lot more types of assignments for a particular subject, but do not generalize. Therefore interdisciplinary use, for example as *the* e-Assessment application of choice for an institute of higher education, is not well supported.

It has also to be taken into account, that these systems are designed to work within a regular web browser. Therefore additional security, for example by using a lockdown application (see Section 3.3), has to be provided in order to prevent cheating. Since a regular web browser is not per se designed to be a secure environment for e-Assessment, the implementation of a lockdown is more difficult than in a setting where the e-Assessment application is specifically designed to run within a secure context.

3.3 Lockdown

There is a wide variety of lockdown applications available, for example the SafeExamBrowser[6] by ETH Zürich, LockDown Browser[7] by Respondus, KioWare Lite[8] by KioWare or Questionmark Secure[9] by Questionmark (Frank, 2010). These tools are, however, not platform independent. SafeExamBrowser for example is available for windows operating systems and macOS, LockDown Browser is actually only available for windows operating systems. The other tools cover also platforms like Android or iOS, but none of the tool is available for Linux, let alone ChromeOS. Additionally, some of the tools must be purchased in order to use them, therefore introducing new costs.

Additionally, online proctoring system are available, for example Kryterion Online Proctor[10], ProctorFree[11] or ProctorU[12]. These services make use of the webcam to monitor the student sitting in front of the computer, therefore verifying the student's identity. Some of these services provide additionally a special application, which has to be used throughout an exam. These tools provide some security, which goes into the same direction as a full-blown lockdown application, but do not cover the same set of security features (Foster and Layman, 2013).

4 METHODOLOGY

The research carried out in this PhD project is based on the design based research methodology (Wang and Hannafin, 2005). The research process consists of the following main steps:

1. Identification of the Problem
2. Design and Implementation of Prototypes
3. Evaluation of the Prototypes / Refinement of Requirements
4. Implementation of the final e-Assessment Framework
5. Final Evaluation

The particular steps will be described in the following sections.

4.1 Identification of the Problem

Based on experience in teaching at institutes of higher education, it became obvious that e-Assessment is not well integrated into higher education. Especially in the field of computer science, however, e-Assessment would greatly benefit the examinations by bringing the main subject of study - the computer - into the examination. Therefore it was decided to investigate why e-Assessment is not better integrated into higher education. Two main reasons became obvious: money and a lack of available tools that work

[4] https://moodle.org/

[5] http://www.ilias.de/

[6] http://safeexambrowser.org

[7] http://www.respondus.com/products/lockdown-browser

[8] http://www.kioware.com/kwl.aspx

[9] https://www.questionmark.com/content/questionmark-secure

[10] https://www.onlineproctoring.com/home.html

[11] http://proctorfree.com/

[12] https://www.proctoru.com/

out of the box. Especially the latter keeps reservations against e-Assessment existent. Hence the implementation of an e-Assessment framework, fulfilling certain requirements and supporting BYOD, was considered a potential solution to the identified problems.

4.2 Design and Implementation of Prototypes

4.2.1 Conception of the Prototypes

Based on the identified problems and the proposed solution, different BYOD approaches will be implemented as prototypes and evaluated afterwards. These prototypes will be based on scenarios described in (Küppers and Schroeder, 2016).

It seems most promising to provide the students with a special software to ensure security throughout the examination, instead of relying on a secured network. Especially since mobile internet is available to everyone at an affordable price, it would not be controllable if any of the students would bypass the secure network by utilizing an LTE adapter or the like. This situation is depicted in Figure 3.

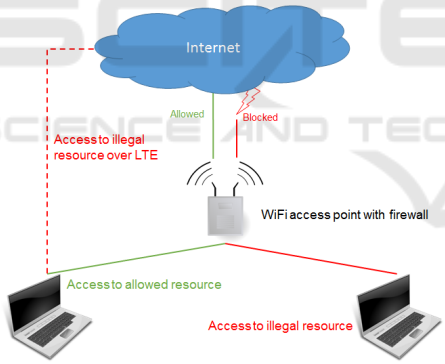

Figure 3: Bypassing a secured network over mobile internet.

However, if mobile internet can be suppressed effectively, for example by structural measures, then a secure network could be added on top of the e-Assessment framework in order to provide an additional layer of security. For the design of the prototypes it is assumed, that access to an uncontrolled network is available, therefore the prototypes have to take care of the security themselves. Hence, three scenarios remain as basis for a prototype: the students' devices as...

1. ... workstation with a lockdown application
2. ... workstation with a provided operating system
3. ... thin client for a VDI

Since a VDI can provide only small savings - if any - in comparison to a traditional centrally managed IT infrastructure (Microsoft, 2010)(Microsoft, 2014)(Intel, 2011), this scenario would contradict the starting point of utilizing BYOD in order to save money. Therefore only two scenarios remain, which will be implemented as prototypes. Both prototypes are described briefly in the following sections.

4.2.2 Students' Devices as Workstation with a Lockdown Application

For this scenario, the prototype will consist of three main components:

1. The e-Assessment Application
2. The Lockdown Application
3. The Examination-Server

The e-Assessment application will be a program that serves as the front-end of the examination. It will present the assignments of the examination, which are received from the examination-server, to the students and also provide suitable ways of entering their results, which are sent back to the examination server. For a programming assignment, for example, the e-Assessment application could provide a text editor with syntax highlighting. Beyond the basic examination-related capabilities, the e-Assessment application will provide an interface, which the lockdown application can use in order to work properly.

The lockdown application will prevent cheating during the examination. Since the e-Assessment application is intended to be platform independent, the lockdown application has to be adapted to the particular operating systems. In order to lower the threshold for problems with the functioning of the lockdown application on the students' devices, it is desirable to not require administrative privileges, because not all students may have these on their devices. This could be, for example, the case if a student employee is allowed to use a device that is provided by its employer. By not requiring administrative privileges it may be possible that not all actions, that could be used for cheating, can be prevented. The lockdown application can, however, detect these actions. In its simplest case, the lockdown application could check whether the e-Assessment application has lost the focus. If an illegal action was detected, the lockdown application reports to the examination-server.

The examination-server has multiple tasks. First and foremost it provides the assignments of the examination to the e-Assessment application running on the students' devices and collects the results. Second, it provides logging functionality, which is used by the

lockdown application. Additionally it provides further features, which may be needed by different types of assignments. For programming assignments, for example, it could provide a functionality that allows the students to compile and run their source code on the server and get feedback during the examination. The examination-server additionally keeps track of the students' progress during the examination. Therefore, if a student's device breaks down and a backup device has to be used, the student's progress is not lost, but the examination can be seamlessly resumed.

The e-Assessment application and the lockdown application have to be implemented in a lightweight way in order to ensure the previously described equality of treatment. It is also because of the equality of treatment, that the examination-server implements additional features and not the e-Assessment application itself. By outsourcing operations and features to the examination server, all students are treated equally, because they all access the same server.

4.2.3 Students' Devices as Workstation with a Provided Operating System

For this scenario the students have to boot their device with a provided USB stick. This USB stick contains a pre-configured operating system, for example a linux distribution. This operating system is configured in a way that allows the students to do only things that are wanted during the examination. Therefore, only allowed programs are installed and only allowed information are contained on the USB stick. Online resources can be blocked by a firewall, that blocks all online resources except white-listed ones. Since the students do not have administrative privileges on that operating system, they are not able to alter the system's configuration. At first sight, this approach seems to be very promising, but there are potential drawbacks. First, there may be technical problems with booting a device from a USB stick (Frankl et al., 2012)(Alfredsson, 2014). Second, the equality of treatment could be violated if just *some* software is used on the operating system, for example a regular programming IDE or a CAD program. These programs tend to work better on devices that have more processing power and memory available than others. Therefore it could be an option to use the e-Assessment application as software on the provided operating system.

The results of the students can either be saved on the USB sticks or uploaded to a server. The first case would make a network connection potentially expendable. If a student's device breaks down, the USB stick can principally be used on a backup device to resume the examination without loss of data. If the breakdown of a students device, however, damages also the USB stick, all of the student's results so far are lost. Therefore, in order to guarantee reliability during the examination, for the prototype the previously described examination-server could be used to keep track of the students' progress.

4.3 Evaluation of the Prototypes / Refinement of Requirements

Once the previously described prototypes are implemented, a survey will be carried out to evaluate how the prototypes perform in an examination-like scenario. For this purpose voluntary teachers and students will be asked to simulate examinations with the e-Assessment framework. Different issues will be addressed by this survey as listed in the sections below. Both perspectives, the students and the lecturers, will be evaluated to get the entire picture. The results of the survey will then support the decision which prototype will be the basis for the implementation of the final e-Assessment framework (see section 4.4).

4.3.1 Usability

The objective usability is intended to determine how usable a prototype really is in an examination. Therefore the focus lies on newly developed or adjusted software, e.g. the e-Assessment application or the provided operating system. Basically, the aim is to get aware of conceptional issues that decrease usability. Additionally, suggestions for improvement from teachers and students will be collected.

4.3.2 Security

The objective security is intended to determine how secure a prototype really is. Security in this regard has two meanings, which basically come down to the following questions:

- Are students able to cheat despite the lockdown application?
- Are the students' results appropriately saved?

Therefore it will be analyzed whether problems in this regard occurred during the simulated examinations. Additionally the teachers and students will be asked whether they came across a potential flaw in the conception of security related aspects.

4.3.3 Acceptance

The objective acceptance is intended to determine if the e-Assessment framework is accepted by teachers

and students. As already described previously, the acceptance of e-Assessment by teachers and students is an important factor for the success of introducing e-Assessment at institutes of higher education. Therefore the goal is to find out whether there are still reservations against e-Assessment after the simulated examinations with the e-Assessment framework and possibly find ways to sort out these reservations.

4.4 Implementation of the Final e-Assessment Framework and Final Evaluation

Based on the results that were collected during the survey, one prototype will be selected as the most promising one. This prototype will serve as basis for the final e-Assessment framework. The suggestions for improvement from the survey will be used during the implementation. It may be possible, however, that issues are mentioned during the survey that do not come with a proposed solution. To possibly find solutions for this issues, purposeful literature review and potentially another survey could be the tools of choice. This survey would have to be carried out with a broader audience and be specifically aimed at the open issues.

After the second implementation phase, the result has to be evaluated again in order to make sure that the implemented improvements indeed improve usability, security and acceptance of the e-Assessment framework.

5 EXPECTED OUTCOME

The expected outcome of the PhD project is an e-Assessment framework, that fulfills all the previously mentioned requirements. First and foremost it should be accepted by teachers and students and therefore possibly serve as a booster for e-Assessment in general. Since it utilizes students' devices instead of requiring an institute of higher education to maintain a costly IT infrastructure, it potentially lowers the entry hurdle for starting with e-Assessment. Hence, institutes of higher education could simply test the e-Assessment framework without the need of big investments and see if it fulfills their needs or not. Even if the framework does not fulfill some institutes' needs, if these institutes gave feedback, the e-Assessment framework could be improved further. More generally, despite being labeled as the 'final e-Assessment framework' in this paper, the e-Assessment framework could potentially be improved if more institutes of higher education would test it and report issues as well as suggestions for improvement. Therefore it is planned to release the e-Assessment framework as an open-source project with a suitable license, for example the GPL (Free Software Foundation, 2007). This should lower the entry hurdle even more, because on the one side everyone has the possibility to comprehend in detail how the e-Assessment framework works, on the other side it can be adapted to own needs if necessary. Therefore everyone can actively contribute to the further development of the e-Assessment framework.

Beyond the already discussed features of e-Assessment, some additional features were yet mentioned during discussions with peers and teachers. Some of them will be discussed here to give an impression which issues e-Assessment can tackle beyond changing the mode of examination itself.

5.1 Ask a Question

From experience, it is a rather common scenario throughout an examination, that students ask questions about the assignments. For example how a specific part is meant or what is asked for at all. It is also common that the same questions are asked over and over again, especially if the assignment lacks in clarity. So, at some point, the invigilator has to decide to give the hints, which were given to each asking student, to the whole audience. But then, even if the invigilator asks for the whole audience's attention, some students may not listen. So they will keep asking the same question as before. Hence, one additional feature suggested was a kind of Q&A system for the e-Assessment framework. This feature would enable students to post questions to the invigilator, who then could be rejected or answered. If the question would be answered, the questions and the answer would be available to all students. Therefore, each student would get the same information at the same time. Additionally, the other students are no longer disturbed during the examination, either by other students asking questions or by the invigilator giving information to the whole audience.

5.2 Individual Time Measurement

Sometimes, even if the examination sheets have been placed on the tables before the students were allowed to enter the room, it is not possible to track whether all students turn the sheets all at the same time. Or, despite starting to write something being forbidden, while the examiners explains some things after the students were allowed to read the assignments, some

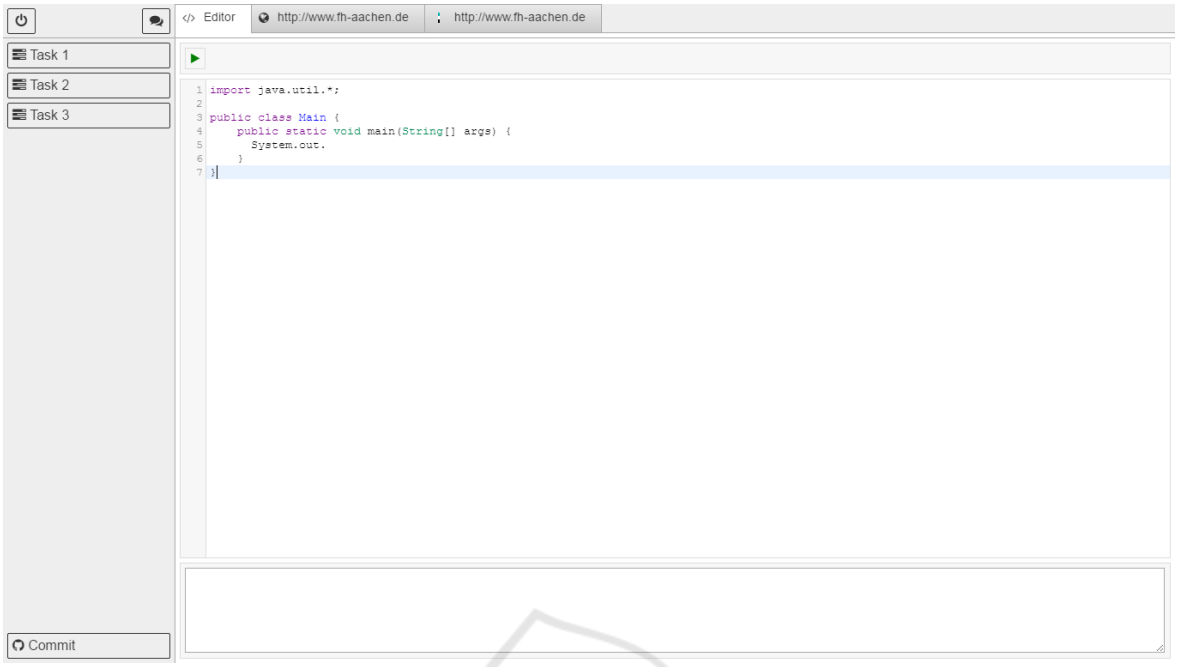

Figure 4: First version of the e-Assessment application.

students may chose not to obey that. These issues can potentially lead to situations, where some students have in practice a few more minutes to work on the examination, than other students. Therefore, another suggestion was made regarding the time measurement of the examination. The e-Assessment framework could not measure time globally, but individually for each students. Hence, each student would have n minutes to work on the examination, regardless of whether the student chose to listen to the examiner at the start of the examination or wanted to start working right away.

6 STAGE OF THE RESEARCH

In this paper a proposal for an e-Assessment framework was presented. At the moment a first version of the e-Assessment application is implemented. A screenshot is shown in Figure 4. The previously proposed feature set is admittedly not fully implemented at the moment. The examination-server is available as far as the actual state of the e-Assessment application needs it for testing. Additionally, the lockdown application for windows operating systems (starting from Windows® 7) is also available. A bachelor thesis that deals with the lockdown application on linux-based operating systems is written at the moment. Altogether, it is planned to have everything implemented and to carry out the first survey in fall 2017.

Quite recently the PhD project was granted a funding by the German Stifterverband (Stifterverband für die Deutsche Wissenschaft e.V., 2016). Therefore the project is already known to a general public. That fuels the hopes that the PhD project can indeed be a booster to e-Assessment once it has been finished.

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