

# ICT-SUPPORTED PROBLEM-BASED LEARNING: POSSIBILITIES OF APPLYING PROBLEM-BASED LEARNING FROM PRIMARY SCHOOL TO HIGHER EDUCATION

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**Abstract:** Problem Based Learning was originally created for medical students to better diagnose new illnesses; this methodology can be used in almost all the fields of education. Teachers can teach by appealing to students' natural instincts to create, and they can improve the students' performance in different disciplines. So, we can say that it is an easy way of the acquisition and integration of new knowledge. While the content and structure of PBL courses may differ, the general goals and learning objectives tend to be similar. It begins with the assumption that learning is an active, integrated, and constructive process influenced by social and contextual factors. The task of our paper is to show how Problem-Based Learning can be used from primary to university level education in teaching different subjects.

**Keywords:** problem-based learning, learning approach, ICT

## 1. Theoretical background of PBL

Beyond the discipline-based knowledge there is a greater expectation for “real-world” competencies (Boyatzis, 2008), which have value at the labour market (Machin et al., 2001). Besides the needs of the labor market, there are other “examinations” like TIMMS and PISA, where the students and also the different educational policies have to pass successfully. To achieve a good result at the different international student assessment programs, there is a great need of different competencies like self-directed learning skill, general problem-solving skill and social skill (Hense et al., 2003). At the same time these types of competencies are hard to separate and foster only within individual subjects. If this is the case, the question comes easily: how these competencies can be developed. Different educational systems and different schools try to find the “Holy grail” of the method, which can be applied effectively in the classroom. There is a constant criticism against the traditional educational philosophy which considers the teaching-learning process as a single transfer, and it is based on instructions (Hense et al., 2003). In the other plate of the scale –as an alternative possibility– there are the constructivist approaches (Reinmann–Mandl, 2001 cited by Hense et al., 2003). The problem-based learning (PBL) can be that learning environment which can blend and unite the “two worlds” of educational philosophies; it contains the advantages of the instruction-led teaching (brief overview of the topics, the help in the beginning) and the advantages of the constructivist approaches (Hense et al., 2003). According to Barrows and Tamblyn (1980:18) Problem-Based learning can be defined as “the learning that results from the process of working toward the understanding or resolution of a problem. The problem is encountered first in the learning process and serves as a focus or stimulus for the application of problem solving or reasoning skills, as well as for the search for or study of information or knowledge needed to understand the mechanisms responsible for the problem and how it might be resolved.” PBL can develop the above mentioned and expected skills and it helps to form a positive and proactive learning attitude.

### 1.1. The possible developed skills with the use of PBL

There are numerous different skills which can be developed with the use of PBL. The following list of these developed skills doesn't reflect any ranking, each and every skill has the same importance. After all one of the most mentioned skills is the self-directed learning skill (SDL). In a PBL environment the learning is organized around real-world problems; as the students are keen to find the roots of the problems and solve them, they almost automatically become self-directed learners (Torp & Sage, 2002). SDL is a learning process where individuals control their learning needs, define their goals, find their resources, choose and build their learning strategies, and evaluate the learning outcomes (Loyens et al., 2008). PBL helps to develop critical thinking skills as well as improves problem-solving skills. In PBL environment the students can learn how to analyze a problem, how to collect relevant facts, how to generate hypotheses and how to identify the necessary information to make reasonable judgements to solve the problem (Şendağ & Odabaşı, 2009). A problem-based learning environment can develop communication, respect and collaboration. These skills can also help to provide the preparation for future skills in the ever-changing world of information (Vardi, Iris; Ciccarelli, 2008). The fostering of interpersonal skills and teamwork means better student interaction, teamwork and richer interpersonal skills (Vernon, 1995), like peer evaluation, working with group dynamic (Delafuente et al., 1994); leadership qualities, decision-making by consensus, and constructive communication between team members are also developing (Tricia & Moore, 2007). With the evolution of the self-developed learning, the extrinsic motivation can turn into intrinsic motivation, therefore the effect of PBL can last longer because of the inner drive motivation. Different studies (Sungur & Tekkaya, 2010; MacKinnon, 1999) focusing on the motivational effects of PBL can affirm that group discussion positively influences students' intrinsic interest in the subject matter discussions. With the usage of new media technologies, the PBL can effectively develop digital/technology literacy skills and vice versa. The technology can broaden the possibilities, make the learning process faster in PBL environments; likewise, PBL can be an effective constructivist pedagogical approach to apply with the emerging number of ICT devices in the education.

## **1.2. The possible developed learning attitudes with the use of PBL**

The problem-based learning environment with the above-mentioned skills can make several changes in students' learning attitude. With the self-developed learning and the intrinsic motivation, the students are actively involved in the learning process; as they are the constructors of their own knowledge therefore PBL can foster the student-centred learning (Antepohl & Herzig, 1999). They can be better at determining their own goals based on their interest, they can be more experienced in locating adequate information, they can take more responsibility for their own learning process; these practices can efficiently help to uphold lifelong learning (Candy, 1991). This also means that a kind of self-motivated attitude, which causes a higher percentage of attendance in PBL classes comparing to other (traditional) classes. As Vernon & Blake (1993) state, this can reflect the students' positive attitude toward this pedagogical approach, therefore they become self-motivated. With the applying of PBL real life situations take part in the centre, which means students are motivated to find the solutions; in this meaning the emphasis is on the comprehension not on the facts. In this method, (online) discussion forums, collaborative research and knowledge-building can take the place of lecturing. These activities also mean that PBL helps deep learning, in-depth learning as it brings students and learning materials closer to each other as well as it connects everyday activities with new concepts. After all problem-based learning approach actively builds new knowledge on prior knowledge which affirms the relevance of constructivist approach (Wood, 2003). As the students have their learning goals, they know the relevance and applicability to the learning material, it leads to better understanding and adeptness. More challenging and significant problems help them to be more proficient (Albanese & Mitchell, 1993). The real life, real world problems, and the context of these problems makes the knowledge more profound, lasting and increase the transferability of the skills from the classroom to work (Gallagher & Rosenthal, 1992). At last but not least, learning outcome counts; PBL students score higher than the students in traditional classes, which mean higher level of learning. Their learning attitude; complex, context-based knowledge; self-assessment techniques; data gathering, methods, and their more effective communication helps the better understanding and retention of knowledge (Bridges & Hallinger, 1991).

## **2. ICT supported PBL**

Problem-based learning and other project-based learning approaches can be supported by the new media technology and different devices of ICT. At the same time these technologies without a useful method may be of little help in education. It wouldn't be very rational to wait for any positive changes in the school only because of the computers. After all the use of new media technology offers the possibility to PBL to have its role in the classroom (Tulodziecki, 1998 cited by Hense et al., 2003). The problem-based learning approach and the "modern digital knowledge" are relatively close to each other. The different skills developed by PBL and the expected and popular 21st century skills have a lot in common. To be more exact the skills of the 21st century can be divided into three main categories: (1) learning skills (critical thinking, creative thinking, collaborating, communicating), (2) literacy skills (information literacy, media literacy, technology literacy), and (3) life skills (flexibility, initiative, social skills, productivity, leadership) (P21, 2015). As it becomes visible the majority of the expected skills are really identical. Moreover, the use of technology opens new horizons in the application of problem-based learning and helps to make the learning process faster and more effective. Internet makes the asynchronous (e.g. e-mail) and synchronous communication (e.g. chat) possible as well as it fosters the collaboration of the students. The multimedia offers new possibilities to the constructive creation, presentation and publication of different topics and ideas. The computer-based games and simulations give the opportunity to examine problems from several views and contexts. Additionally, the online data gathering fosters the self-directed learning and the critical approach of the learner. To sum up, with the applying of multimedia and ICT the place, time, method and pace of the learning can be more personalized and flexible (Hense et al., 2003).

### 2.1. Using ICT in the process of PBL

Several approaches exist which try to help to plan and carry out a PBL project by divide it into different steps and phases (see Genareo & Lyons, 2015; Moursund, 2005). We used Genareo & Lyons's (2015) and Moursund's (2005) steps as a base point to develop a general structure of planning a problem-based learning project. By synthesizing the different steps, we got four main phases: (1) planning; (2) information gathering; (3) from plan to product; and finally (4) assessment (see Figure 1.). In order to build up a clearly visible process we ordered the different ICT devices, tools and online activities to our above-mentioned phases.

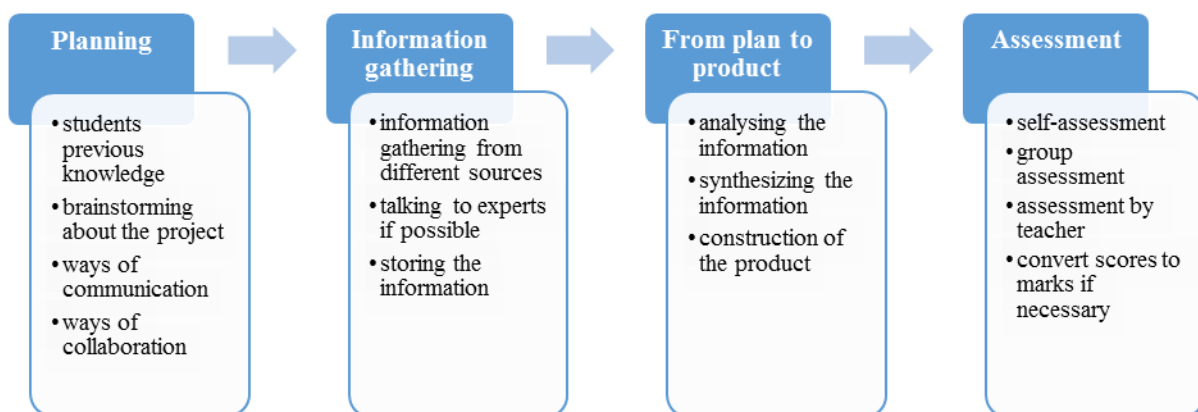


Figure 1. The phases of a problem-based learning project

The planning means the first steps of a PBL project; in the beginning it is advisable to map what the students already know about the topic. This can be easily and effectively done by using different online solutions like mentimeter.com (to get a poll or "wordcloud" in real-time) and online quizzes. To take one step closer to the project a brainstorming can be organized to flash different views and context of the problem. After making groups (maybe with TeamUp) several technical questions can be discussed, like the structure and the methods of assessment of the project, the possible ways of communication and collaboration. For keeping eyes on process/project management trello.com can come handy, and also the well-known learning management systems can be used as a base platform (e.g. Moodle, Edmodo). The ways of communication can cover a wide range from e-mail, chat to

social media (e.g. Facebook, Twitter, Instagram, Google+), and also the platform of collaboration can be various (e.g. Padlet, Titanpad, Linoit, Google Docs).

After the problem has been introduced to the students and the first couple of steps have been taken, the participants can start the information gathering for the project. As in the process of PBL the self-directed learning is highly important, a well-structured plan for information gathering is essential; this can be fueled by different sources (internet: Google, Google Scholar, Wikipedia, other search engines and online encyclopedias; public libraries). Talking to different subject matter experts is also a possible and interesting solution (via e.g. Skype, Google Hangouts, Viber). The gathered information can be stored at various online places (e.g. different LMS, Evernote, Wikis, Google Drive, OneDrive) and can be shared easily.

As most of the project-based learning approaches PBL projects often have a kind of product in the end of the session. “From plan to product” phase is a very active section within a PBL project as the students analyze, synthesize, and use the previously gathered information to derive knowledge from it. With the final product of the project the students have to be able to show what they have learned. They can work collaboratively with the stored and shared information in the school or anywhere else online; the cloud-based applications (storage places, digital note-taking apps) can be very useful and handy in the communication and also in the workflow. The product of the project can have various forms according to the subject, topic, level of education and of course the creativity of the students always can find new paths. The ICT-supported PBL often leads to a product, performance, or presentation—or, some combination of these three (Moursund, 2005): short videos (e.g. digital storytelling with Movie Maker), video blogs (vlog), blogs, websites (e.g. Wordpress, Drupal), presentations (PowerPoint, Prezi), collages, online canvases (Padlet, Linoit), publications and various types of performances can be produced. Moreover, most of the digital products can be enhanced with augmented reality (AR, maybe using Aurasma) and virtual reality (VR) in order to have a complex result.

Hence the traditional tests do not measure all the skills and abilities which sometimes have key-roles in a problem-based learning project, the assessment of the above-mentioned products and the final assessment of the students in the end of the project can also be various, and it is naturally different than in a traditional classroom situation. The teacher (or rather facilitator) is amongst the students during the project, walking around the classroom (or being online in the virtual world, e.g. Second Life), observing and have informal conversations with the groups or individuals (Moursund, 2005). In this way active and instant assisting (e.g. time management guidance, milestones), teaching (e.g. according to IT-based or subject matter-based questions), and also assessing can take place. In the planning phase the expectations and the conditions of the fulfilment were laid down, hence it can be the fundament of the assessment. As the PBL is a student-centred approach, therefore the participants can also evaluate their own progress (for younger student’s rubrics can be helpful); in this meaning every student can be evaluated by himself/herself, by the group and finally by the teacher. Feedbacks can be given in a “gamified” way using ClassDojo or Classcraft. The observations (by the teacher) and the different self-assessments, as well the stored project-products (a digital portfolio can be used) can be evaluated and they can be converted to points or scores, which can be turned to marks if necessary.

### 3. ICT-supported PBL projects in practice

As it may become visible the problem-based learning approach offers possibilities along with freedom to the students and to the teachers also. In the same time this freedom has to turn into self-directed learning in order to be a successful learning process. Whether this responsibility may only be taken by older students or PBL can be implemented at other levels of education? On the strength of our experience we realized that problem-based learning approaches can be implemented at different levels of education, from primary school to higher education. Naturally some methodical aspects of the projects may differs slightly but generally the structure and after all the effectiveness of the learning approach remains the same. In the following part we introduce several ICT-supported PBL projects from primary school to higher education.



### 3.1. ICT-supported PBL projects in primary school

The PBL project took place in a middle-sized primary school in Budapest, Hungary. As the school is successfully running its own „Tablet supported education” project pupils and teacher had previous experiences with ICT. In spite of the innovative attitude project-based learning approaches remained rare in the school’s pedagogical methods. The organized PBL-project involved one fifth grade class (age 10-11, ISCED 2011 level 2; n=11) and four teachers (Geography, IT, English as a foreign language, Arts). The project lasted for three weeks and covered approximately twelve lessons from three subjects and numerous hours after school. The main topic of the PBL-project was the “Planets” and the raised problem (question) was “Where is our place in the Universe and what possibilities do we have after the Earth?”.

Before the beginning the three participator teacher discussed the basics and the main goals of the project. The leader facilitator was the Geography teacher as the main topic belonged to him, the two other teachers helped the pupils with different ideas and information as well as technical support (e.g. ICT-based issues). In the planning phase the pupils organized their groups on their own and discussed the base of the topic with the leader teacher (Geography). The structure, the time-frame and the assessment of the project were developed, discussed and then uploaded to a shared online canvas (see Figure 2.)

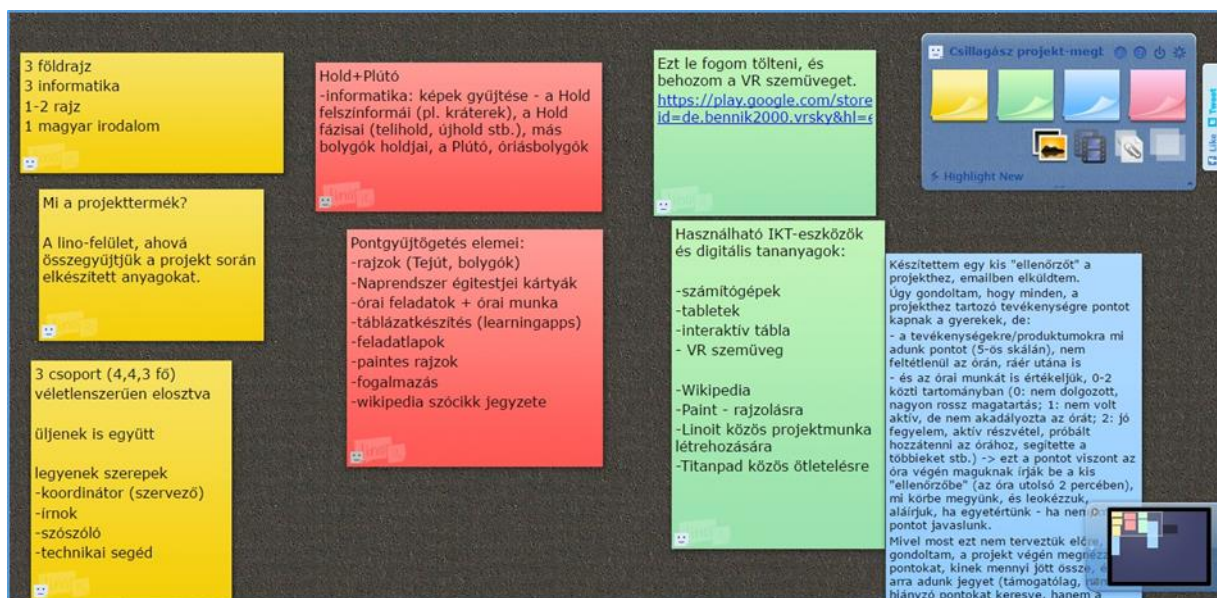


Figure 2. Online plan of a problem-based learning project in Linoit

The pupils gathered information from different sources as they could use a wide range of ICT devices (e.g. tablets, smartphones, desktops) and visited the school library regularly. They collected, downloaded and stored information on their own storage place on the school’s network. The students collaborated extremely well, they used different ways of communication on top of that they applied different devices to have an effective knowledge-sharing.

After the gathered information had been analyzed and synthesized, the pupils started to establish their project-product. Some of them chose to edit a short video, some of them chose to make a PowerPoint presentation (see Figure 3.). During the creative process they also gained a bunch of technical knowledge (e.g. english, ICT-related questions, how to refer to articles), „just-in-time learning” happened naturally. The pupils motivated and inspired each other very well, the different groups turned to each other if they needed additional information; they could use each other’s ideas in a creative and non-competitive way. They also wanted to try and implement new technology in their project like augmented reality and virtual reality.

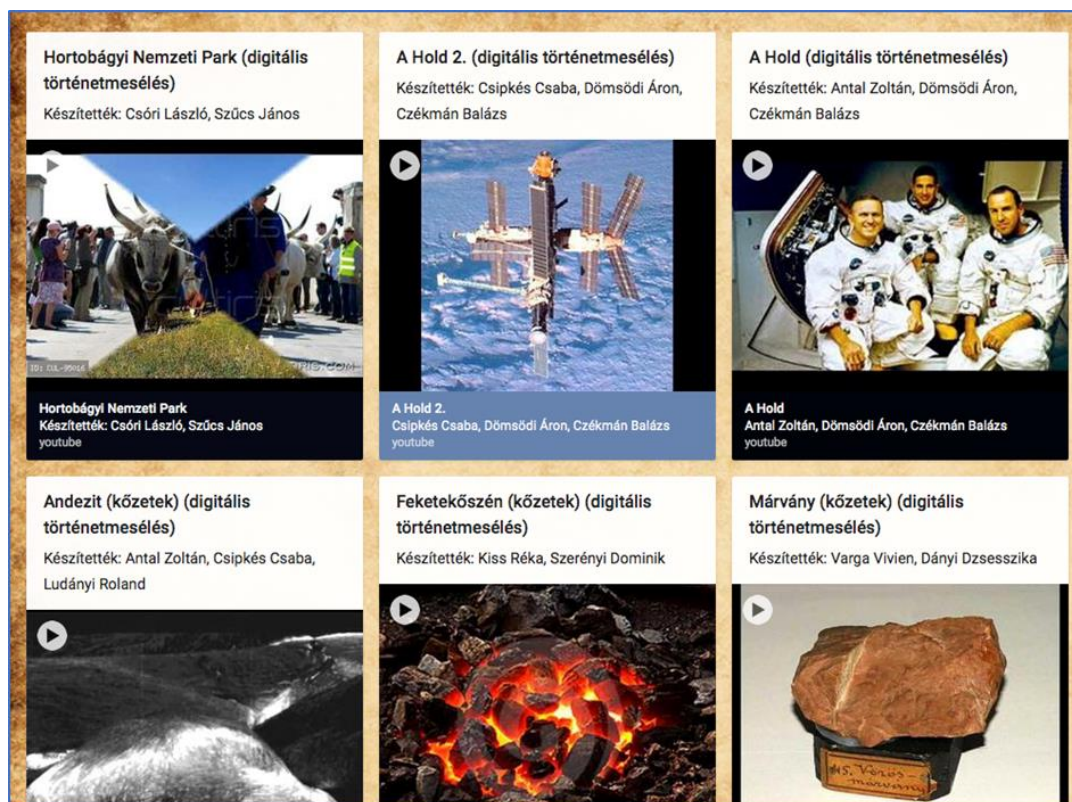


Figure 3. Pupil's products in Padlet

The whole project was observed by the four facilitator teachers therefore the assessment was continuous. During the different phases the pupils collected their scores in a small rubric; they needed a very few assistances of doing this as well they were very critical with themselves. They felt their freedom during the whole PBL-project, and therefore they tried to be very consequent with their work. They used ICT tools, internet frequently as an information source (search engines, Wikis), as a platform of communication (chat, e-mail), as a tool of creation (Paint, Word, PowerPoint) and as a platform of collaboration (Linoit, Padlet, LMS).

### 3.2. ICT-supported PBL projects on language lessons

However, many teachers do not know about this method, they usually use it on their lessons. Languages cannot be taught traditionally, because students have to develop all their skills, so this method is very useful for them. Of course, the existing knowledge influences learning, and the expectations have an effect on the performance. The most effective way of learning is practice.

The first step is to be conscious of what information they already know about the problem, what information they need to know to solve it and the strategies to use to solve it. Being able to articulate such thoughts helps students become more effective problem-solvers and self-directed learners. As many students are not capable of this sort of thinking on their own, the instructor must become a coach. When I would like to keep the students active I present them with a problem, not assignments or exercises. So, they have to find the solution themselves. Here is an example to make it is easy to understand how PBL works in language learning: the teacher/coach identifies the ill-structured problem of using simple past and present perfect tenses, explains the structures and the basic differences. After presenting the problem, the learners explore their pre-existing knowledge then they collaboratively discuss it in detail. They identify the resources, share the tasks, compile the findings, prepare worksheets on the topic and finally they propose solutions. Nowadays we can find ICT devices in many schools as new and creative ways of learning are supported. The computers play a significant role in the learning process especially in learning languages. The most up-to-date teacher's books contain interactive whiteboard material, which accompanies the book and incorporates all the material included in the student's book and workbook. However not every room has an interactive board, a computer room or a room with a projector is also enough to motivate students with PBL. It is

a fact that any kinds of application that we use in the classroom improve and enhance the better lesson. The computer assisted language learning is flexible, rich, interactive and effective, so it can support the use of PBL.

I often give the students such homework that they have to search for the answers on the internet. I believe it is much easier for them to learn and remember terms they have to look for. So, it is a kind of challenge for them. When we want to do an exercise on tenses, before starting it we usually talk about what we already know about them, we they list out possible solutions to the exercises and they have to find the solution by themselves. Occasionally students get a topic and the next lesson they have to make a power point presentation in front of the class. They are free how to build it and what information they include. Sharing their findings is an opportunity in demonstrating what they have learned.

Problem-Based learning can provide students with opportunities to examine and try out what they know, they discover what they need to learn, they develop their skills, they improve their communications skills, or they state and defend positions. The main advantage of PBL is that students become actively engaged in meaningful learning and they are able to practice the knowledge and skills in a functional context.

### **3.3. ICT-supported PBL projects in higher education**

Facilitating language learning in higher education tends to be neglected in many cases: teachers often believe that at this level most students have already gained such a level of learning autonomy that it is not necessary to facilitate their process of learning strategies. However, this seems to be rather a preconception as in many cases students do appear to be under-motivated, overworked and overstressed due to the requirements of their degree courses or the expectation of accomplishing language exams. The Hungarian educational regulation of language examination has put pressure not only on the students and their teachers but also on the methodology and the curriculum. The primary objective of foreign language education currently in Hungary is to pass a language exam; it seems as if the issue of applicable knowledge has completely been neglected and forgotten. The employment of new technology, inventive methodological arsenal and a refreshed attitude can help a paradigm shift in foreign language teaching in Hungary.

This section of the article aims to draw the attention to a project-based language course in higher education. The course in this form was a pilot occasion, and it turned out to be both a professional and a personal achievement. Students showed a significantly increased motivation level, an enhanced engagement, a developed and positively altered learning autonomy as well as a more conscious form of learning strategy. The language of the course was English, and the level of the students was C1, which represents an advanced level according to the European Language Framework. These students (n=12) displayed a highly independent use of sophisticated vocabulary and accurate grammar, furthermore listening to or delivering a lecture in English did not cause any difficulties to them. Their objective was to graduate in the degree course of English for Specific Purposes (ESP) Translation Programme.

However, the general motivation of acquiring the language was often wavering, and it took a lot of effort, time and invention on behalf of the teacher to empower the students. The purpose of employing a project based approach was to facilitate their language learning process, to motivate them and to offer a new way of vocabulary acquisition. The part of the course when the project was launched focused on enhancing and deepening the knowledge of lexical items with a specialised focus on crime and punishment. The 6-week period of project based teaching first concentrated on introducing the most important advance vocabulary of legal and crime-related words. This was processed together with the students following the main principles of PBL: it contained independent learning, it involved self-regulatory approach and understanding the new terms often meant tackling a legal issue or a problem. The second half of the 6-week period focused on the realisation of the projects: the students were asked to create mini creative tableaux in the framework of content-based vocabulary teaching. They were given complete freedom of how to approach the 'crime and punishment' topic. The students worked in pairs and their only requirement was to approach the vocabulary topic from their relevant and specific field of study: the ESP class involved students of history, of psychology, of



Hungarian language and cultural studies. The projects (see Figure 4.) turned out to be completely relevant and intriguing works of art: the history students created a tableau of prison history in the Victorian era. The beauty of the project was not only astonishing, but the language used in the descriptive elements of the product demonstrated a profound understanding of the expected lexical items.

Some students of psychology delved into the history of serial killers, focusing on the mindset, some famous culprits, infamous and notorious events. They highlighted the recurring pattern in the behaviour of the murderers. Some other students prepared a comparative tableau of fictional detectives (eg. Sherlock Holmes) and their film adaptations. They demonstrated a detailed knowledge of the film versions and their relevance to the age of their production.



Figure 4. Projects of students of higher education

All these examples proved that project-based classes, problem-solving oriented periods – even within a course – did facilitate the acquisition of new lexical items. Students employed new terms and words applied in their own specific field of study and research. It was striking to observe how students became engaged in their project-making and how co-operation and managing a project eventually from scratch in English resulted in positive and empowering experience for both teacher and student.

#### 4. Summary

According to literature in this topic, PBL has many risks concerning the students, the instructor and the institution. As for students it requires more time and takes away study time from other subjects. It creates some anxiety because learning is messier, and less content knowledge may be learned. As for instructors, creating suitable problem scenarios is difficult and it requires more preparation time. As for institutions, it requires a change in educational philosophy for faculty, which will need staff development and support. It is a fact that it works best with flexible classroom space and it engenders resistance from faculty who question its efficiency, but if we take into consideration that we can offer an enjoyable and satisfying way of learning for the students I think it is worth it. While the traditional way of teaching focuses on memorization, this method encourages greater understanding and higher rating of their abilities. Furthermore, the skills can be fostered effectively and the learning attitudes can be changed positively as well with the usage of ICT-based problem-based learning.

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