



SOFTWARE SOLUTION FOR 3D MODELLING AND ITS APPLICATION FOR EDUCATION IN INDUSTRIAL ENGINEERING

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ABSTRACT

The paper deals with the selection of a correct software solution for educational purposes in the field of 3D modelling. Five most suitable options were chosen. This article describes each variant. For the selection process itself, a set of factors was created to compare software in the aspects most important for the teaching process. This led to the choice of the most suitable alternative. Subsequently, learning materials were created for the software. Those were then tested in an experiment. The main goal was to evaluate the suitability for integration into the learning process, either for individual study or as potential teaching aid for 3D modelling lessons.

KEYWORDS

3D modelling, software solution, education, software selection.

1. Introduction

Nowadays 3D modelling became vital part of many industries. From entertainment to simulation, 3D modelling helps to increase the effectiveness of the chosen process [8]. 3D models also help to visualize new concepts, which can be used as tools for adapting to a constantly changing manufacturing market [9]. Proper planning is required here to find all possible solutions and set the correct criteria [4]. That is why choosing the correct way of modelling that suits user's needs can be crucial for a smooth workflow. One of the factors is a selection of the software. However, choosing the right one can be a difficult task. One needs to consider all important parameters and the function required for the job.

2. Software solutions

The basis of modelling lies in the selection of the right software. The market offers many variants, and its choice is conditioned by several factors, which may be based on user preferences or company requirements.

The decisive factor is how we intend to use the chosen solution. In this case we were looking for a software suitable for integration into education. This means it

is vital to consider how various options would impact the teaching process. How well would students adapt and how would overall quality of the lesson change? Of course, there are many factors, but the most important thing is to define all of them before the decision-making process itself.

From the wide range of options, five software products were chosen. These were selected based on previous 3D modelling experience of the author, as options that are sure to provide satisfactory result as 3D modelling tools. While all of them could potentially enrich the teaching process, it is important to consider all factors before making any hasty decision. The selected software are:

- Autodesk 3ds Max,
- Maya,
- Blender,
- Cinema 4D,
- Houdini.

2.1. Autodesk 3ds Max

The Autodesk 3ds Max is a software developed by Autodesk Inc. It provides a range of powerful tools for 3D modelling, animation, rendering, dynamics and composition. These tools allow game developers, architects, designers, technicians, and visualization professionals to create stunning artwork. The program offers

an intuitive user interface and tools for a smooth workflow and simplification of the modelling process. It allows the use of procedural modelling and direct manipulation techniques. In addition, a large library of various modifiers improves and simplifies the entire modelling process for a beginner or intermediate user [6].

2.2. Maya

Maya is another software developed by Autodesk Inc whose work environment is designed not only to support the work of an individual but also for a group of people working in the production chain. Its interface consists of many tools and other functions that create an intuitive and complex modelling environment. Maya uses the so-called dependency graph that provides an overview of the various nodes and the dependencies between them. Each scene consists of nodes connected to a network. The interface contains editing windows that allow you to intuitively link these nodes and edit the information within them. The dependence graph is contained in the so-called hypergraph [3].

2.3. Blender

Blender was developed by the Blender Foundation company. Blender was originally a commercial program that became “open source” when the company faced some issues. This transition was the catalyst for its popularity, and today Blender is supported by a large and talented community [2]. Blender is a software for 3D modelling and animation. It provides all the tools needed to create models that can be further used for rendering or to create animations in the same software [1]. This software boasts an impressive set of tools for modelling and digital sculpting (a modelling method based on model deformation) and can be considered a full-fledged alternative to paid modelling solutions. Blender has been infamous for its non-standard operating procedures, but the above-mentioned update addresses many of these issues.

2.4. 4D Cinema

Cinema 4D is software developed by MAXON Computer and is used to create 3D scenery and visual effects. Cinema 4D is used by architects and designers to create 3D graphics, realistic animations, visualize products and much more. It can also import 2D and 3D models of all used formats. It is an intuitive software containing tools such as digital sculpting, an advanced particle system, a hair physics system and so-called “MoGraph”, which is a major module of Cinema 4D for procedural modelling and animation [7].

2.5. Houdini

Houdini is top notch node-based software developed by Side Effect Software. This gives the user high flexibility and performance at the cost of higher learning requirements. Software is based on procedural modelling. Houdini is among the best in 3D modelling support,

providing a wide range of features and tremendous performance [5].

3. Choosing the suitable software

Before starting the modelling itself, it is vital to choose the most suitable software. Each possible variant offers unique functions and workflow. Each has its advantages and disadvantages that need to be considered and evaluated. It is important to choose a modelling software that meets the given parameters and demands to the highest extent. Answering these questions can make the selection a little easier:

- Does the software contain all the necessary functions?
- Does the user know how to use it? If not, is it hard to learn?
- How high is our budget? Is this software within its range?

For the selection process, the set of factors vital for software as a teaching tool were chosen. In addition, each factor was assigned an importance value on the scale from 1 to 5, where 5 is the largest deciding impact. These factors and their importance values are based on a subjective opinion of the author and his previous experience with 3D modelling learning. However, the fact that software will be used in an education institution is taken into account.

Table 1
Decisive factors and their importance value.

Decisive factor	Importance value
Price	5
Education options	4
Complexity	3
Learning materials availability	2
Ease of “follow along”	5
Number of features	3
Accessibility	5
User interface	5
Software compatibility	3

Even though objective factors are important, the subjective view of the users should not be neglected. The opinion of the user and “feeling” of software can be as important as objective parameters.

Since the main purpose of software shall be education, the decision-making process should be adjusted to suit such a goal. That is why all decisive factors are set to accommodate every possible issue or feature of teaching process. The following figure (Fig. 1) shows the decision-making process while looking at all selected factors. Some of them are based on subjective opinion rather than facts, however, as mentioned before, the “feeling” of the software can also be crucial.

After careful consideration, the modelling software Blender had been chosen. The deciding factors were mainly its price and accessibility since all the option offered more than satisfying performance, so it would

be difficult to base the decision on that. Moreover, those two factors were also assigned the highest importance value. In this case Blender is completely free and student can install it on limitless number of machines in their school, homes, or dorms. Along with intuitive and organized workspace, Blender is a great choice for modelling beginners and teaching process. Moreover, basic modelling knowledge can be easily transferred into different software that could possibly be used in their future jobs.

	3ds Max	Maya	Blender	Cinema 4D	Houdini
Price	\$1,620 /year	\$1,620 /year	FREE	\$719 /year	\$1,995 /year
Education options	One-year educational access for free.	One-year educational access for free.	Free without any restraints.	Free license valid for 6 months.	\$75 /year for schools or free apprentice license for students
Complexity	Relatively easy to learn.	Relatively complex for beginners.	Relatively easy to learn.	Relatively easy to learn.	Complex for beginners
Learning materials availability	Plenty of free or paid courses.	Plenty of free or paid courses.	Plenty of free or paid courses.	Plenty of free or paid courses.	Plenty of free or paid courses.
Ease of "follow along" (How well could students replicate the instructions)	Easy to follow along	Fairly easy to follow along	Easy to follow along	Fairly easy to follow along	Some students may find it difficult to follow
Number of features	Has every necessary feature.	Vast numbers of features, all necessary included.	Has every necessary feature	Has every necessary feature	Vast numbers of features, all necessary included.
Accessibility	Registration and proof of enrolment (i.e., student ID) required.	Registration and proof of enrolment (i.e., student ID) required.	No registration, or through Steam account.	Registration and proof of enrolment (i.e., student ID) required.	Registration required.
User interface	Beginner friendly environment, highly intuitive.	Highly intuitive.	Beginner friendly, organized, highly intuitive.	Beginner friendly environment, highly intuitive.	Organized, highly intuitive.
Compatibility with other software	Possible exports in most used formats (FBX, OBJ etc.)	Possible exports in most used formats.	Possible exports in most used formats.	Possible exports in most used formats.	Possible exports in most used formats.

Fig. 1. Software comparison.

4. Software application for education

Blender was chosen as the most suitable option for integration into education process. But, in addition to the software, the means to learn it are required. So, the next step is the creation of a guide explaining the basic workflow in the software. The two most suitable options are either text or a video form. In this case, the text manual was created explaining all the basic functions. Figure 2 shows a preview of manual itself written in Slovak language.

This manual will be freely available to any student and can be used as a guide for complete beginners. Moreover, students can use it to look up a particular method, such as principle of certain functions and modifiers.

The manual contains two basic exercises. Modelling of a table and a chair. After completing those students can move on to their own projects. However, they still can use the manual since it contains step by step instructions for the execution of basic functions.

For the effectiveness evaluation experiment, student was given the manual and reference photos of an object with basic dimensions. His task was to model the object using the manual and Blender. Prior to this experiment,

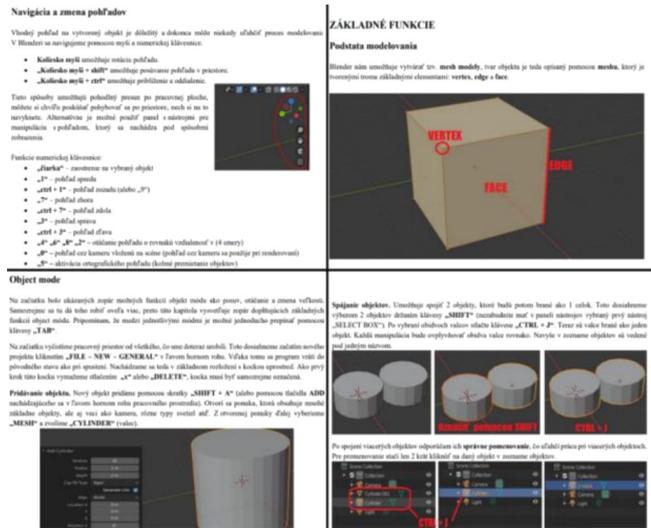


Fig. 2. Blender workflow manual.

the student had minimal experience with modelling software and modelling itself. The student read through the manual and completed included exercises. Then he started to model the assigned object with the help of reference photos. Figure 3 shows the process of modelling of an assigned object – a pallet jack.

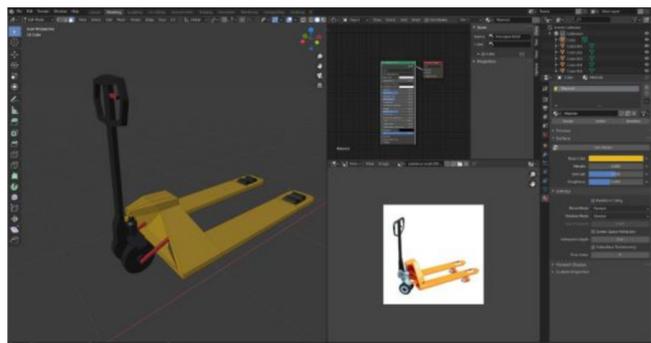


Fig. 3. Process of modelling.

The student completed the assignment within a one week. The final object was considerably simplified, which is understandable. The student was almost a complete beginner, so making realistic copy would be too challenging. After the experiment, the short interview was held with the student. He said that the manual was easy to understand and he found instructions for every necessary function required for the pallet jack modelling. He was asked how he would improve the manual. In his opinion the main thing missing was the video demonstration of the functions.

In the end, manual proved to be quite effective and could be used as a teaching material suitable for 3D modelling lessons. Additionally, another experiment is planned. However, this time the number of participants will be increased. A larger sample of students will provide even more data to perfect the manual as a tool for self-study or teaching.

In addition, one of the students used the manual to create objects for his virtual workplace in 3D. It helped

him to create all the models he needed to build his virtual scene. Simplified models were also used in this case to reduce the performance demands, since this workplace would be used for virtual reality application. Figure 4 shows the result of basic 3D modelling in Blender in combination with game engine to create a virtual reality application.



Fig. 4. Models created using Blender for virtual environment.

5. Practical use

The presented 3D modelling solution and the modelling guide proved to be useful during its testing with students. However, the real challenge is to integrate the proposed methods into practical use.

One of the proposed uses is its application into the process of design of manufacturing systems using VR. To create a quality scene, it is necessary to model objects that look like their real-life counterparts. Those objects are then imported into game engine (such as Unity 3D) to create a VR capable virtual environment. Its parameters are adjusted to suit the needs of the project. Figure 5 shows a designed manufacturing system, which was transformed into virtual environment. This form was then used as a presentation tool to show the participants the details of the design. They could use the VR headset to navigate through the scene and explore all parts of the proposed manufacturing system. Naturally, all objects needed for this virtual environment were modelled using the proposed software.

Another proposed solution is staff training using virtual reality. In this case, however, the attention to detail while creating required models must be even higher. Users will be interacting with the created models. This means all control instruments (such as buttons, levers etc.) must be in exact position, looking exactly as their real-life counterpart. This makes the modelling process even more demanding but the high-quality result can significantly reduce the qualification or requalification cost. Created models are imported to a game engine, where the scene and training scenario creation takes place. Figure 6 shows the virtual training of machine tool operation. A user (an employee) can try his tasks in virtual environment before he is delegated into manu-

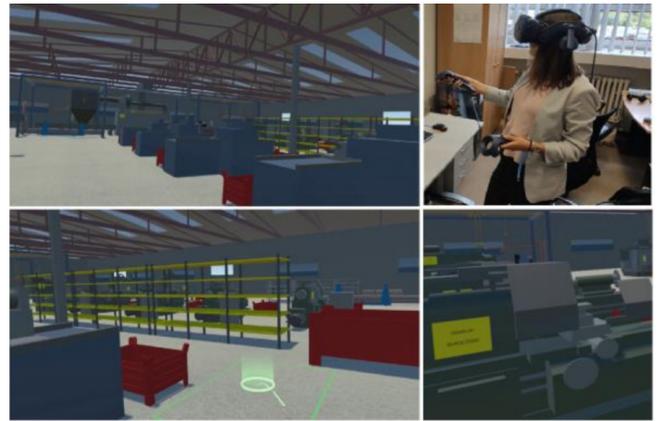


Fig. 5. Manufacturing system design using VR.

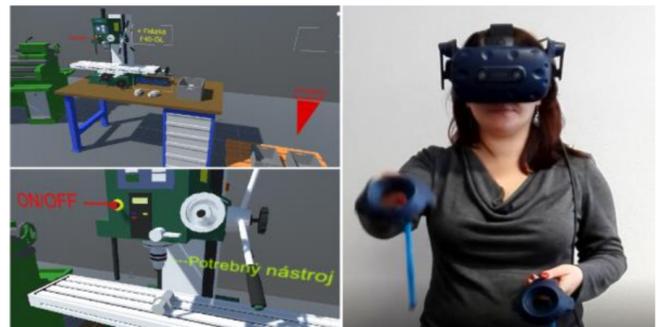


Fig. 6. VR training.

facturing process itself. The user uses a VR headset and controllers to complete the assigned job while the application guides him through the process step by step. Models were created using the proposed 3D modelling software solution with the presented modelling guide.

6. Conclusions

In conclusion, the market is filled with high quality software capable of fulfilling various demands in various spheres. Five presented solutions are just the tip of the iceberg, but the majority of users would find one of these satisfactory for their projects. However, users are encouraged to explore the market to search for the ideal option matching their requirements. Moreover, both objective and subjective factors need to be considered to reach balanced evaluation between quantifiable parameters and user preferences. In the end, it all depends on expectations of an institution or an individual set to satisfy all requirements determined in search for ideal software solution.

Eventually, the final choice was Blender software. The great strength of this software is the fact that it is free and yet it can compete with its paid competitors. This creates an ideal environment for beginners for learning the 3D modelling. Thus, it is a great choice for integration into educational process.

Learning materials for the selected software were also made. The created manual will provide necessary information for a modelling beginner. The result of the experiment showed that quality of manual is satisfacto-

ry for potential implementation into the teaching process. However, it can also serve as a tool for self-study, which is free to download and available for every student. Additional experiments will be held to further improve the manual.

The last chapter presents two options of integrating the presented solution into real life practice. Utilizing the selected software and creating a modelling guide for the design of manufacturing system in VR or for the creation of virtual reality training for employees. This unifies the process of modelling of the required objects and simplifies the workflow.

Lastly, it is safe to say that Blender software solution was the right choice. So far it managed to meet all expectations set during the selection process. Complimented with efficient teaching materials it will surely become a strong addition to the education process.

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