

The Design and Implementation E-Scaffolding Enhance Learning (ESEL) Using Web-based Simulation on Moment of Inertia

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ABSTRACT

In this study, E-Scaffolding Enhance Learning (ESEL) using Web-based simulation has been designed and implemented. The scaffolding approach in this research is a conceptual scaffolding of the moment of inertia. Web-based simulation consists of 2D and 3D simulation. The 3D simulation was developed using unity software and 2D simulation was developed using scratch and articulate storyline software. All simulation was published as an Html file, and finally inserted into the website. The validation of the product was carried out by experts such as a physics lecturer and a physics teacher. The implementation phase was carried out through collaborative distance learning between one Senior High School in Bandung and one school in West Nusa Tenggara. The validation results show that ESEL using Web-based simulation on moment of inertia is deserved with an average score of 92% in the very good category. Nevertheless, there are several improvements still need to be made in terms of the appearance of the Web-based 3D simulation especially when it is accessed by phone cell. The appearance of the Web-based 3D simulation is still not responsive for smartphones. But based on the questionnaire result of students, ESEL using Web-based simulation on moment of inertia has a value 71% which means that ESEL has a good category of validation and is interesting for the students. ESEL using Web-based simulation also improves students' activities in the distance learning of physics classroom.

Keywords: Scaffolding approach, Web-based simulation, Distance learning

ABSTRAK

Penelitian ini bertujuan untuk mengembangkan dan mengimplementasikan *E-Scaffolding Enhance Learning* (ESEL) berbantuan simulasi *web*. Pendekatan *scaffolding* dalam penelitian ini merupakan *scaffolding* konseptual mengenai konsep momen inersia. Simulasi *web* yang digunakan terdiri dari simulasi 3D dan 2D. Simulasi 3D dikembangkan menggunakan aplikasi *Unity* dan simulasi 2D dikembangkan menggunakan *platform* daring *scratch* serta aplikasi *articulate storyline*. Semua simulasi disimpan dalam format *file* Html kemudian dimasukkan ke dalam *website*, sehingga dapat digunakan oleh pengguna dimana saja selama terhubung internet. Validasi produk dilakukan oleh dua ahli yang melibatkan dosen dan guru fisika. Produk ESEL diimplementasikan dalam pembelajaran jarak jauh secara kolaboratif antara salah satu SMA di kota Bandung dan di Nusa Tenggara Barat. Hasil validasi menunjukkan bahwa ESEL berbantuan simulasi *web* pada konsep momen inersia layak digunakan dengan skor penilaian sebesar 92% (sangat baik). Hasil implementasi menunjukkan bahwa tampilan ESEL khususnya pada simulasi 3D untuk beberapa *smartphone* masih ditemukan kendala sehingga masih perlu perbaikan. Respon peserta didik terhadap penggunaan produk ESEL sebesar 71% (baik). Selain itu, ESEL juga mampu meningkatkan aktivitas peserta didik selama pembelajaran daring.

Kata kunci: Pendekatan *scaffolding*, Simulasi berbasis *web*, Pembelajaran jarak jauh

INTRODUCTION

Since March 2020, all learning in schools must be carried out using distance learning due to the spreading of Covid19 virus. Covid19 pandemic has spread to more than 200 countries in the world and has affected the world of education (Hamid et al., 2020). There are several websites available as learning resources for students or learning materials for teachers but they are just contain subject matter content, there is no special website for inquiry-based learning that improve students' scientific activities. However it is the most important as a process and product of science learning (Yusuf & Wulan, 2016; Saprudin et al., 2021; Saprudin et al., 2022). One of the lessons that can improve students' scientific activities is inquiry learning. Scientific skills include observing, analyzing and predicting and can be improved through inquiry learning (Sataloff et al., 2019). However, based on initial observations in several schools, remote inquiry learning is less difficult for teachers due to limited resources. This is because the equipment needed for the experiment is not available in the environment around the students. In addition, teaching materials that provide distance learning in Indonesian language are still lacking. Teaching materials and media, one of the other difficulties in presenting inquiry learning remotely is providing direction to students on how to carry out these scientific activities.

Based on the above problems, in the implementation of distance learning through scaffolding approach using Web-based simulation. Through this approach, students will be given concepts from the simplest, gradually to the complex one and finally get independent in learning. One study states that the scaffolding method assisted by PHET simulation can improve students' critical thinking skills and science process skills (Dasilva et al., 2019; Ardiyati et al., 2019). Another study showed that Web-based ESEL approach is an effective self-directed learning tool for online physics classrooms (Sarah, 2022). However, inquiry learning will be difficult if students do not have basic skills, scientific skills. To get scientific skills, students need to get guidance first. One research showed that Therefore, in this study, a scaffolding approach will be used. Students will get assistance in learning through a website that is specifically designed so that students are active in distance learning (Wilson et al., 2011; Tyagi, 2012; Konstantinidis et al., 2013; Toledano, 2013).

The simulation will be published in the website to get many advantages including being multiplatform (doesn't depend on the operating system used), responsive design (remaining responsive on both mobile phones and computers or laptops) and interacting. This website will be specially designed using a scaffolding approach in presenting subject matter and investigations. The presentation of the material is presented in an integrated manner, both theory and practice, so that it will build the knowledge of students in constructivism as well as improve their scientific skills. This web-based application can be accessed either through a computer/laptop or smartphone with a responsive and interactive display. This application is named ESEL, namely Electronic Scaffolding Enhance Learning. With this application, it is hoped that during distance physical learning, students can still carry out learning that improves their scientific skills.

In simple terms, scaffolding can be interpreted as temporary adaptive support or assistance with the ultimate goal being the independence of students (Jumaat & Tasir, 2014; Smit et al., 2018). Teachers develop temporary support structures for students to reach new understandings that they cannot achieve independently (Linder et al., 2006). Although initially students are given guidance or assistance, gradually the assistance is reduced to achieve their independence goals. Wood, Bruner, and Ross argue that scaffolding allows a child to solve problems, carry out tasks or achieve certain goals (Dasilva et al., 2019). Scaffolding has three levels. The first level is the

provision of the environment (Dasilva et al., 2019). At this level, the teacher provides a learning environment in the form of learning resources, media, providing motivation and enthusiasm.

The second level is explaining, reviewing and restructuring. At the second level, the teacher interacts directly with students. The teacher provides opportunities for students to see, touch, explain concepts in their own language. Finally the teacher gives the students articulation expressions in a better language. At this step the teacher helps students solve problems by providing examples similar to those given (Dasilva et al., 2019). The last is the third level, developing conceptual thinking. At level 3, the teacher gives more abstract assignments to students so that students can develop conceptual thinking. Students can also develop representation tools that are in accordance with the concepts being studied (Dasilva et al., 2019).

Traditionally, the concept of scaffolding involves the teacher as an agent who develops how the scaffolding is implemented. However, currently the concept of scaffolding has been extended to software with the concept of software as an implementation of a scaffolding approach that helps students learn (Quintana & Fishman, 2006). Guzdial (1994) introduced software-realized scaffolding by describing how the conceptual aspects of scaffolding can be implemented in software (Quintana & Fishman, 2006). (Quintana et al., 2004) developed scaffolding design framework for inquiry science learning with stages of sense making, process management, articulation and reflection. Scaffolding design framework by Quintana, et all (2004) is a reference developing ESEL in this study. The framework can be seen in table 1.

Table 1. Scaffolding design framework (Quintana, 2004)

Scaffolding Guidelines
Science inquiry component: Sense making
Guideline 1: Use representations and language that bridge learners' understanding
Guideline 2: Organize tools and artifacts around the semantics of the discipline
Guideline 3: Use representations that learners can inspect in different ways to reveal important properties of underlying data
Science inquiry component: Process management
Guideline 4: Provide structure for complex tasks and functionality
Guideline 5: Embed expert guidance about scientific practices
Guideline 6: Automatically handle non salient, routine tasks
Science inquiry component: Articulation and reflection
Guideline 7: Facilitate ongoing articulation and reflection during the investigation

METHODOLOGY

This study used a 4D research and development model, namely define, design, develop and disseminate. The research step can be seen in Figure 1. The define step is product definition, which is to explain the product in more detail. The first is defining the concept of ESEL framework, what are the sequences and what are the keys to each sequence. Afterward defining the concept of physics concepts and the decomposition of these concepts into simpler concepts. In this research, the Moment of Inertia concept was divided into 2 main sub concepts, they are moment of inertia of particles and moment of inertia homogeny objects. In the product definition, we also define specifications of the minimum device to access ESEL.

The second step is design, starting from the design of the learning structure or the flow of learning activities for each of the respective sub-concepts. The third is development of ESEL Web-based simulation so that it can be accessed online. The development of 3D simulation used unity as an application and it was published as an html file for every sub concept. But for 2D simulation, scratch as an online platform was used to make some simulations. Finally for the

strategy scaffolding or problem solving example, an articulate storyline was used to make every step sequentially.

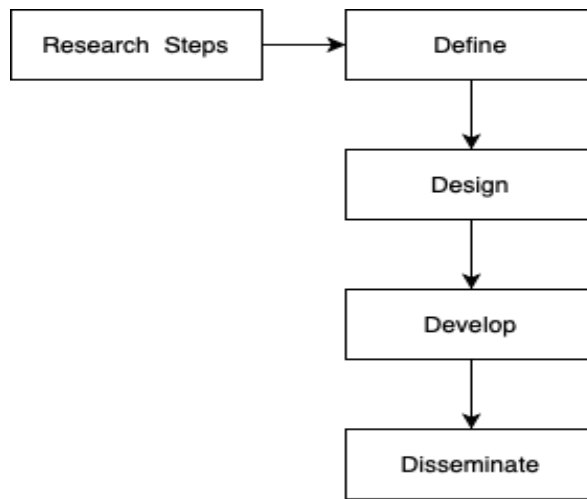


Figure 1. Research steps

In the development step, ESEL was validated by the expert. Before being implemented, ESEL was validated by a physics education expert from the lecturer and physics teacher then a readability test was carried out by several students. After ESEL was developed according to the design, then ESEL was implemented in distance learning at two schools with different characteristics, one Senior High School in Bandung and one Senior High School in Kota Bima. Meanwhile, to determine the validation was analyzed by calculation of score from students' responses to the questionnaire as table 2.

Table 2. Table of validation questionnaire

Questions	Score			
easy to use	1	2	3	4
interesting display	1	2	3	4
help for self-directed learning	1	2	3	4
more interactive than paper book	1	2	3	4
complete materials	1	2	3	4
easy to understand	1	2	3	4
enhance motivation	1	2	3	4

The percentage of validation is calculation as :

$$percentage = \frac{total\ score\ of\ responses}{maximum\ score} \times 100\% \tag{1}$$

RESULTS AND DISCUSSION

The development of E-Scaffolding Enhance Learning (ESEL) approach in this study refers to the framework proposed by Quintana, et al. (2004) with some adjustments for distance learning. There are 3 components of inquiry science in the scaffolding that will be used. They are sense making, process management, articulation and reflection. For every step of simulation, there are activities including these 3 components.

The scaffolding design for distance learning in this study used Web-based simulation as learning media, both synchronous and asynchronous. The design of ESEL in this research can

be shown as use case diagram in figure 2 for conceptual scaffolding and figure 3 for strategy scaffolding.

There are 3 sequences of scaffolding in ESEL of moment of inertia. The first scaffolding is about moment of inertia of particles. First scaffolding has 3 steps. The first step is a concept of value moment of inertia is influenced by mass of particle. The second step is a concept of value moment of inertia is influenced by distance of particle to centre of rotation, and the third step is the combining concepts. For every step, there are 3 components of scaffolding including sense making, process management, articulation and reflection.

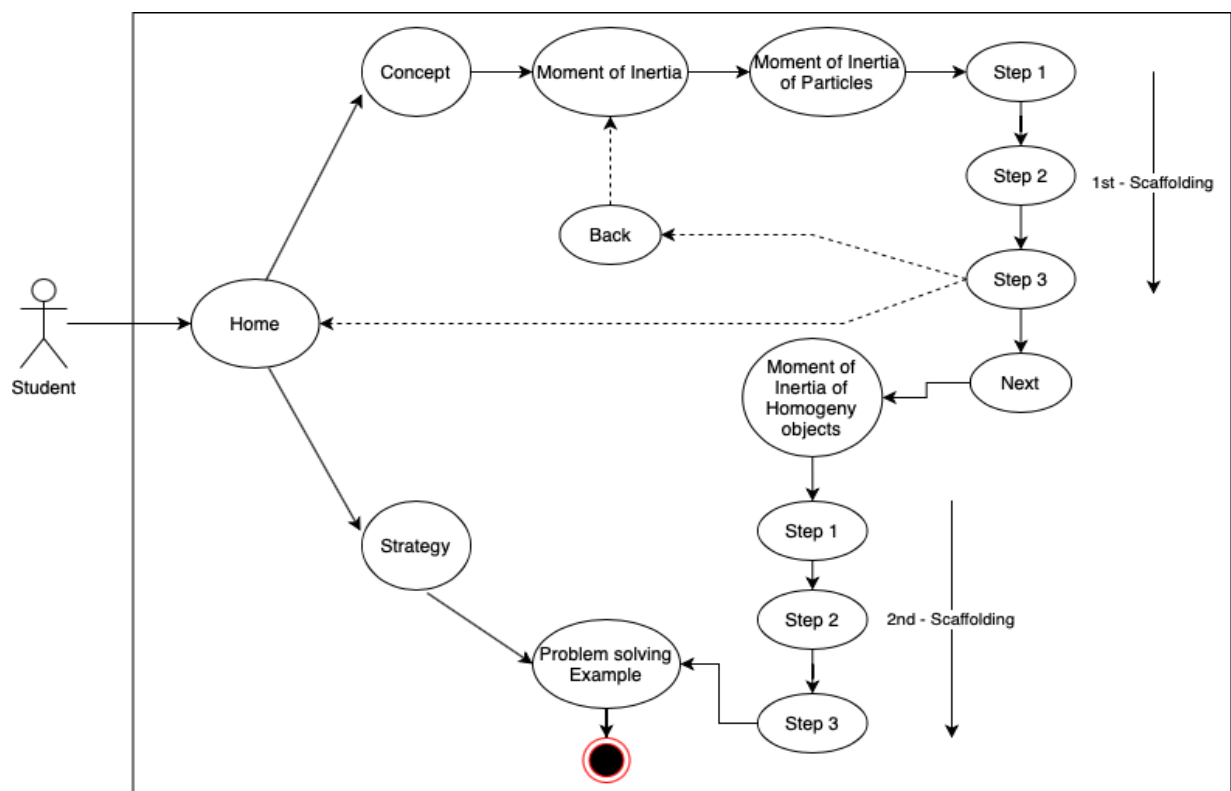


Figure 2. Use case diagram of ESEL

The second scaffolding is about moment of inertia of homogeny object. For every step, there is different activities which students have to complete. In the first step, student just make an easy predict and click answer question. Afterward, students did exploration using a 3d object on the incline floor and found the velocity when the object arrived on the flate floor. Finally in the third step students have to make a matching game of formula of homogeneity object's moment of inertia.

The last scaffolding is about scaffolding strategy, is an example of problem solving. ESEL will give an example on how to solve a question about moment of inertia. Use case diagram for strategy scaffolding as seen as figure 3.

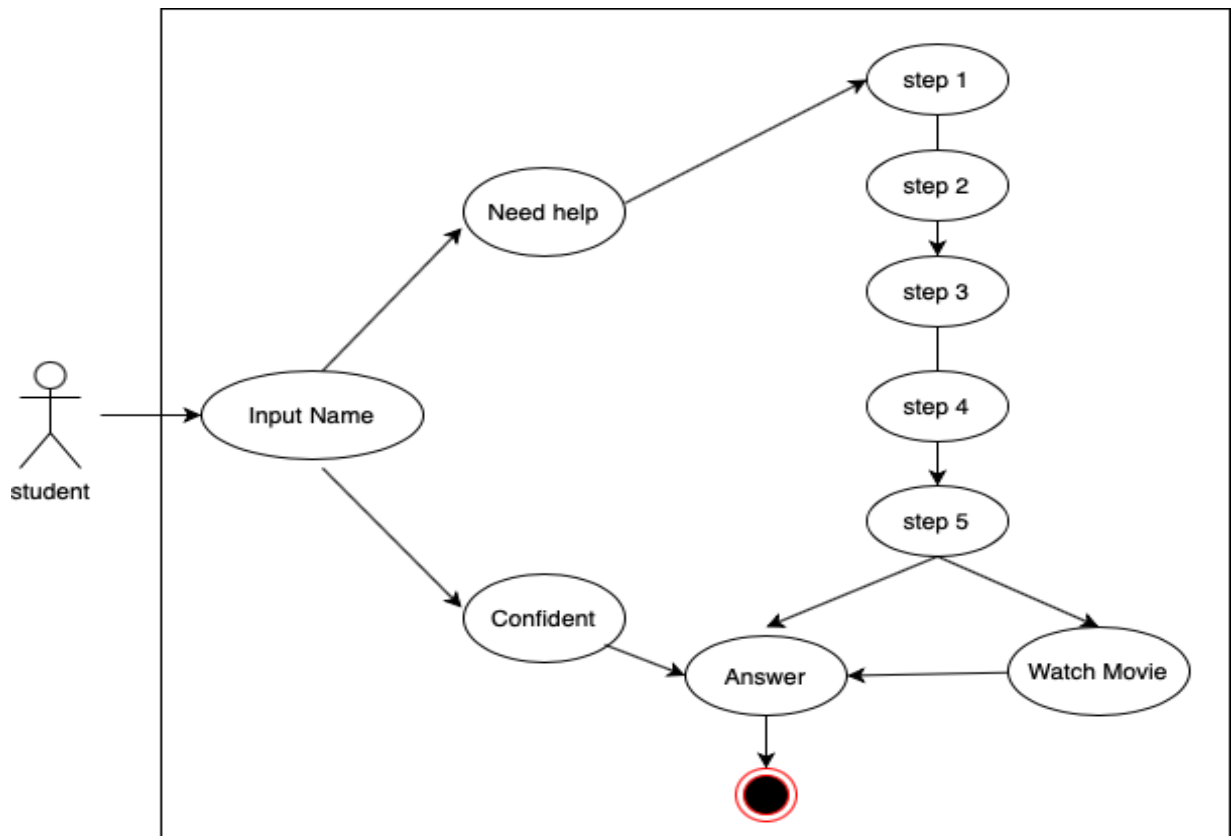
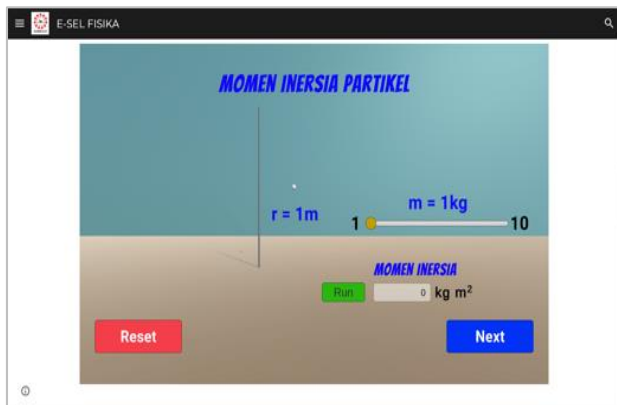
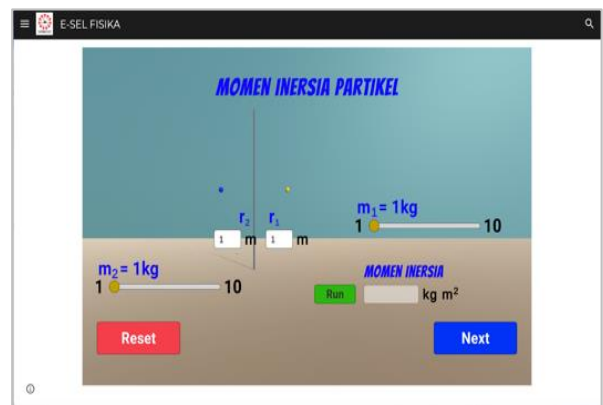


Figure 3. Use case diagram of ESEL problem solving example (scaffolding strategy)

Some examples of ESEL using Web-based simulation in this research can be seen as figure 4, figure 5 and figure 6.



4.a

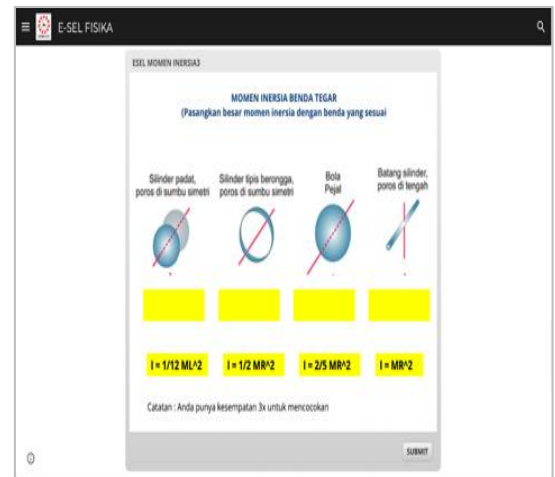


4.b

Figure 4. ESEL moment of inertia of particle (1st scaffolding)

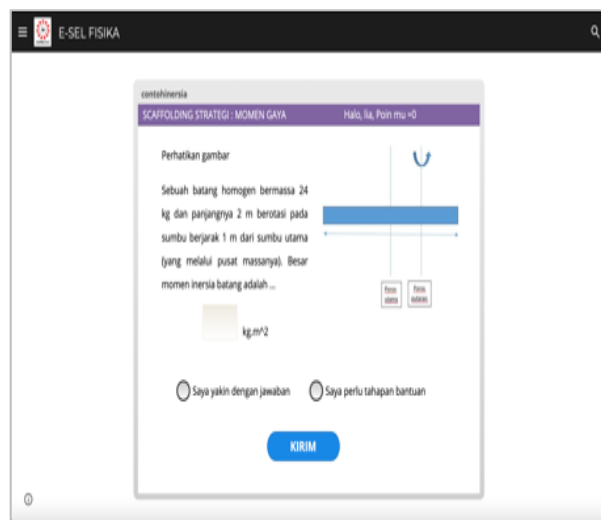


5.a

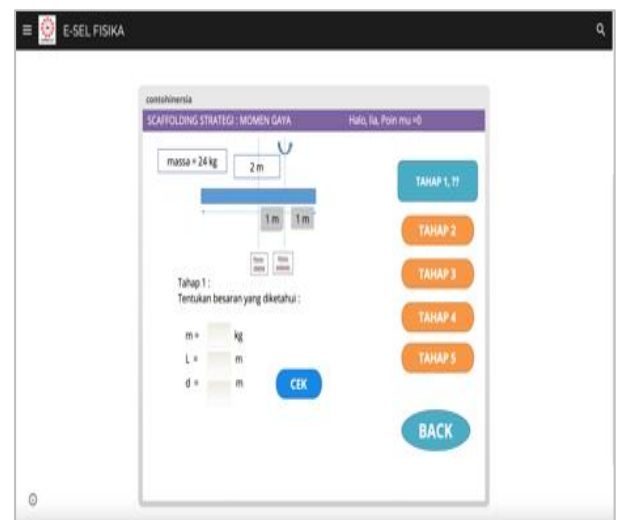


5.b

Figure 5. ESEL Moment of inertia of homogeny object (2nd scaffolding)



6.a



6.b



6.c

Figure 6. ESEL problem solving example (3rd scaffolding: scaffolding strategy)

The full version of ESEL using Web-based simulation was used in this research can be accessed on the website <https://www.e-sel.belajarstem.id>. To get better experiences in using ESEL in the website, please use computer/laptop/smartphone with internet available, browser application such as safari, chrome or mozilla and minimum RAM is 3 Gb.

Design of ESEL using web-based simulation was validated by two people, physics education lecturer and a physics teacher. The results of the validation can be seen in table 3.

Table 3. Validation result

Validation aspects	Validator 1	Validator 2	Average
Design	100%	100%	100%
Product	86%	97%	91%
Material	75%	94%	84%
Average	87%	97%	92%

Based on the validation percentage of 92%, ESEL using Web-based simulation developed are feasible to use. However, some improvements are still needed, the initial concept before entering the content related to prior knowledge of students. Then, in the initial view, it is necessary to include a concept map to see the hierarchy of specific general concepts, their proportions (relationships between concepts) and cross-cutting concepts. Another improvement is to make the display more attractive, for example add sound to each simulation. While the content of the material is very good, both in terms of the concept and in terms of the language used, it is also communicative. Finally in the material content is that it still needs improvements and application examples as well as making the scaffolding strategy more open.

Based on the students' responses through the questionnaire, ESEL-using Web-based simulation on moment of inertia that have been developed are in the good category with a value of percentage 71%. Some inputs given by students to improve ESEL include the 3D display that is not responsive on mobile phones and the duration of the display which is sometimes quite long. This can be circumvented by converting the 3D simulation in the form of an apk file so that it can be accessed without the need for internet provided that the file has been installed first.

CONCLUSION

Based on the results of the discussion that has been described, it can be said that ESEL using Web-based simulation in moments of inertia concept is useful to use. The validation results show 92% in the very good category although some improvements are still needed. The results of implementation in collaborative distance learning between SMA Labschool UPI and SMAN 1 Kota Bima show that ESEL using Web-based simulation that have been developed can improve student learning outcomes with a normalized score gain of 0.73 in the high category of learning effectivity. However, based on the experience of students during implementation of ESEL using Web-based simulation, some improvements are still needed, especially in the display of Web-based simulations, the duration of the exercise and the addition of strategy features for solving complex questions. Based on the results of questionnaires from students, ESEL using Web-based simulation has a value of 0.71 in the good category. Based on the positive findings of this study, ESEL using Web-based simulation needs to be developed and become an alternative for distance learning physics.

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