

ARTIFICIAL INTELLIGENCE ASSISTED LEARNING BLUEPRINT DESIGNER

A. Dingli, L. Caruana Montaldo

University of Malta (MALTA)

Abstract

The Artificial Intelligence Assisted Learning (AIAL) application will be created to help students and assist teachers in primary schools. This application will generate homework and classwork depending on each student's ability. In this study, the primary focus is Mathematics for students aged around 7 years.

One of the essential parts of the AIAL system, mainly used by teachers, is the Blueprint Designer. The Blueprint Designer is used to design the type of questions that will be given to the students together with the possible solutions to these questions. The Blueprint Designer has a drag and drop interface for the teachers to use. This interface is similar to that of a visual programming language. Consequently it is easy to use with a low learning curve and does not require the teacher to have any prior knowledge in programming. The teacher simply selects and drags terms one by one into the question template box and creates a question template by appending these terms together. Various possible question templates are shown in this study.

The Blueprint Designer therefore aims to be a very useful tool for teachers as it will allow them to easily create or amend the questions given to students, namely when the syllabus is modified or if additional exercises need to be added throughout the scholastic year.

Keywords: Blueprint Designer, Artificial Intelligence Assisted Learning (AIAL).

1 INTRODUCTION

The Artificial Intelligence Assisted Learning (AIAL) application is targeted towards primary school students aged around 7 years. The AIAL application analyses each individual student profile and generates personalised Mathematics classwork and homework worksheets tailor-made to their level

The aim of this application is that students find the work assigned to them stimulating and challenging when compared to traditional homework and classwork methods. This application will also correct the given work and provide immediate feedback to the student on their performance in the worksheet. Additionally, the AIAL application will provide analytical feedback to the teacher regarding each student's progress so the teacher will then be able to focus on specific areas of difficulty.

A crucial component of the AIAL application is the Blueprint Designer. The Blueprint Designer is used to create the type of questions to be assigned to students. The solutions to these questions will also be computed in real-time. When the teacher selects and drags a term from a category and then appends it to other terms, a question template is created. Once the "Generate Example and Work out Answer" button is pressed, a sample question is generated so that the teacher ensures that the question template has been successfully created. The question template can easily be amended by adding or removing terms, or deleted if the question template is not the one envisioned. Multiple questions can be created underneath each other and placed in different topics. The teacher also has the option of rating the difficulty level of the question as easy, medium or hard. Once the teacher finishes creating questions and presses the save button, all the questions created are saved into a database which can then be accessed by the AIAL system to generate personalised questions.

The Blueprint Designer's interface is designed so this can be done without needing any prior programming knowledge. Therefore, when the teacher wants to schedule work for the students, the teacher tells the system (through a separate dashboard) which topic or specific exercises should be included in the worksheet given for classwork or homework. Then the AIAL system decides which questions from the database to put into the worksheet and how many questions to give each particular student depending on the individual's user profile. The Blueprint Designer therefore aims to be an invaluable tool for teachers as they will be able to create different question templates according to their requirements.

2 LITERATURE REVIEW

Homework is defined as “the set of school tasks that are assigned by teachers for students to complete outside of school hours”[1]. Lee and Pruitt (1979) described three types of instructional homework purposes: practice (to practice the material that is covered in class), preparation (to prepare the next lesson) and extension (transferring prior learning to new situations)[2] In a separate study about the different types of homework, it was concluded that as a result of extension homework, the primary students’ mathematics achievement was positively impacted. On the contrary, practice and preparation homework did not positively affect the student’s marks. Another result showed that the amount of homework completed did not directly affect the students’ mathematical achievements [3]. Prior academic achievement was also significantly associated with students’ homework behaviours namely, the time students spend on homework and the amount of homework completed. Students who perform poorly tend to spend less time doing homework, manage their time less effectively and complete less homework [4].

According to Felder and Silverman (1988), individuals learn through three learning modalities: visual, verbal and kinaesthetic [5]. Technology-assisted learning tools provide new learning experiences that could help accommodate diverse learners with different learning styles. Ling, Harnish, Shehab (2014) presented active learners with the opportunity to follow along on their own app, while allowing reflective learners the chance to internalize these changing conditions as they happen[6]. The use of direct manipulation with hand and touch sense also allows for kinesthetic learning which could potentially increase student engagement. This aligns with other research that has shown that people are more motivated to learn when they are actively engaged in learning [7]. It was concluded that when learning through examples with the mobile app, students performed better on problems that required them to apply their knowledge[6]. Aberšek and Kordigel Aberšek’s main result showed that for good and effective e- learning tools the philosophical and didactical part is equally or possibly more important than heuristics [8]. This tool implements learning strategies designed to involve the student in the learning process. A high level of interactivity with immediate feedback is also provided. Through these technologies and didactic techniques, the student is placed in an “active” role, as opposed to a “passive” environment of one-way teaching. The teacher can then act as a facilitator of the learning environment rather than being a one-way communicator. Adesina, Stone, Batmaz, Jones (2014) concluded that it is very important for Computer Aided Assessment (CAA) tools to focus on the steps and problem-solving processes that students use when solving mathematical word problems in order to provide more precise feedback [9] Similar performance scores were obtained when the interactive tasks on the CAA environment were compared to paper and pencil tests. In addition, more insight into the student’s problem solving process was provided by the CAA tool. Additional practical benefits of CAA include automatic scoring, rapid feedback and increased accessibility[10]. CAA can also perform Continuous Assessment and analyze the resulting scores. Continuous assessment ensures staged progression which indicates that the tasks the students are working on are challenging as they are slightly beyond their current level.

The specific design features such as immediate feedback, continuous assessment and task repetition, found in the software, probably contributed to the observed learning gains. Thus children can control their own learning and this creates an individualized learning environment that is not typically found in classrooms [11,12]. Learner control leads to better learning outcomes[13] and may create a sense of learning autonomy. Melnyk (2016) concluded that when creating Electronic Educational Game Resources (EEGR) in mathematics for primary school students, the integrity and systematization of learning material is an important criterion. The system should be designed in a way which is interesting and understandable to primary students and the assistance should be clear and precise. In the design of EEGR, sounds should be soft and melodious while soft pastel colours should preferably be used [14].

Outhwaite, Gulliford, Pitchford (2017) showed that large learning gains were sustained when students were re-assessed after five months suggesting that hand-held tablet technology with learner-centered software is effective in supporting early mathematical development [15]. These findings are consistent with other research demonstrating improved mathematical performance in young children following tablet technology-based educational interventions delivered at preschool [16] or at home [17]. Students’ perception and feedback on Interactive Computer Based Learning Systems is very important. Biscomb, Devonport and Lane (2008) concluded that students did not perceive computer-aided assessment (CAA) negatively and staff clearly noted that this form of assessment had certain time saving benefits since it can provide lecturers with a solution to heavy marking workloads. An important finding was the fact that the lecturers acknowledged that the use of CAA was an up-front

investment of time at the start of the module that leads to long-term savings. The time needed to write the bank of questions was then recuperated at a later stage as the marking process was not so time-demanding. In addition, the benefits of CAA for reflective practice were also highlighted as the technology allowed for an analysis of student progression and achievements in relation to each individual question set. A disadvantage was that it is hard to test deeper forms of learning through a CAA [18] In another study a qualitative analysis of questionnaires' results revealed that most students were pleased while working with the evaluated system and that they were open-minded to embrace this kind of learning and teaching support [19].

3 METHODOLOGY

3.1 Overview of Blueprint Design System

One of the essential parts of the AIAL system, mainly used by teachers, is the Blueprint Designer. The Blueprint Designer is used to design the type of questions that will be given to the students together with the possible solutions to these questions. The Blueprint Designer has a drag and drop interface for the teachers to use. The Blockly JavaScript library will be used so the interface will closely resemble that of a visual programming language. Consequently it will be easy to use with a low learning curve and does not require the teacher to have any prior knowledge in programming. The teachers select and drag these terms in order to form a question class/template. These templates are then stored in the Blueprint Database while the respective solutions to the questions will be stored in the Solution Database. The AIAL system will be preloaded with ready-made curricula based upon what is required by national governments. The teachers can then use the Blueprint Designer to add their own material to the system. The Blueprint Designer therefore aims to be a very useful tool for teachers as it will allow them to easily amend the questions given to students, namely if additional exercises need to be added throughout the scholastic year, or when the syllabus is modified.

3.2 Design

The most important point that was considered when creating the design of the Blueprint Designer is that it has a simple and easy to use interface. This is essential as the Blueprint Designer's main target audience is primary school teachers who may have no or little previous programming experience. Therefore, since visual programming languages have a low learning curve, it was decided to create a system which works similarly to Scratch (a well-known visual programming language).

The Blueprint Designer has a drag and drop interface for the teachers to use. The teacher simply selects a term from a category and then drags the term and drops it into the question template box. Terms are dragged and dropped one by one into the question template box and a question template is created by appending these terms together.

Another important design feature that was taken into account is clearly labelled terms and buttons. The category and term names were named using simple vocabulary so as not to be ambiguous. It is for this reason that a help section was also implemented. This "Help: Term Definitions and Use cases" section of the Blueprint Designer features all the terms and provides in depth definitions and examples on how to use the selected term. The buttons "Generate Example and Work out Example" and "Save Question Template" were named to ensure that the interface is easily operated. Moreover the category "Required" contains all the terms "Start", "End" and "Answer" which are compulsory to include when creating a question template.

3.3 Overview of the Help: Term Definitions and Use cases component

The Blueprint Designer contains the following categories: Required, Numbers and Operators, Lists and Sentences, Keywords and Units.

3.3.1 Terms in the Required Category

Start – The start term needs to be the first term in the question template. This signifies that the question template begins from the next term which is appended to it. The next term can be any other term from any category.

End – The end term needs to be placed at the very end of the question template. This is used to mark the end of the question. No terms can be appended to the End term thus ensuring this term is always placed at the end.

Answer – The answer term is essential as it is placed where the teacher wants the user to enter the answer. The answer term can be placed at the beginning, end or anywhere in the middle of the question template. For instance, the students may need to fill in the blank in the middle of an equation rather than giving the right hand side answer to a given equation. The answer term is important as depending on its location the answer has to be calculated using different methods.

3.3.2 Terms in Numbers and Operators Category

Number – When a number term is chosen, the teacher also needs to specify the range in which the number is to be generated. This is done by inputting the minimum and maximum values.

Operators – Once the operator term has been selected, the teacher then needs to click +, -, × or ÷ to place into the question template. The comparison operators > and < can also be placed.

Equals (=) – The equals (=) sign is placed.

3.3.3 Terms in Lists and Sentences Category

List – A list term is used when several related items (that form part of a list) can be placed into the question. The teacher enters the list name and the list items. When a question is generated any word forming part of this list can be placed in that position in the question. It is important to note that the lists are stored separately from the creation of a question that uses the list. Therefore different question templates can access pre-existing lists.

Sentence – A sentence term contains any word or sentence the teacher wishes to include in the question. This sentence will form part of each question generated using that question template.

3.3.4 Terms in Units Category

The unit terms can be placed after a number in order to compare the number with other numbers.

Capacity Units – The capacity units listed are litres and millilitres.

Length Units – The length units which can be selected are kilometres, meters and centimetres

Mass Units – The mass units are kilograms and grams

Time Units – The time units are hour, minutes and seconds.

3.3.5 Terms in the Keywords Category

There are 2 types of keywords: Order and Count.

The Order keywords type contains the order ascending and order descending terms. When either of these two keyword terms is placed at the beginning of the question template, the numbers that succeed the keyword in the question template are sorted in ascending or descending order depending on the keyword chosen.

The Count keywords type contains the count up and count down terms. When either of these two terms are selected, the next number which occurs after the chosen keyword term is used as the number from which the student needs to count up or down by. The next number in the template is then the starting number from which the student begins counting from.

3.4 Different Question Templates

This subsection demonstrates various question templates. The two most common types of questions are: Arithmetic problems and Word problems.

An arithmetic problem is used to directly assess a student's ability to perform arithmetic calculations. On the other hand, a word problem, sometimes known as a story problem, is usually used to test the student's understanding of concepts within a descriptive problem while also testing their arithmetic abilities [9].

3.4.1 Arithmetic Problems

The following question templates (Fig. 1 and Fig. 2) contain the basic Number Operator Number = Answer format. A basic example of this format is: $2 + 5 = 7$.

In Fig. 1: Addition of 2 numbers, the example generated from this question template was $27 + 79 =$ Answer.

Notable points include: the answer term can be found at the end of the question, the first number (27) is generated within the user inputted range (20 to 30) and the second number (79) is also within the specified range (50 to 100). Moreover, as an operator term, addition (+) was selected from the dropdown list of operators.

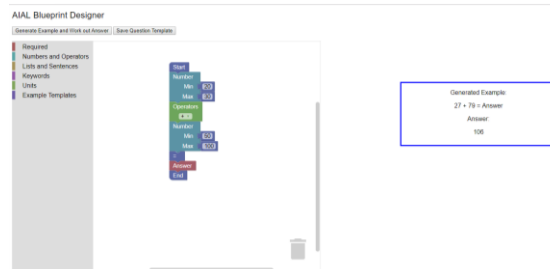


Figure 1: Addition of 2 numbers

A similar question template to the one aforementioned uses the same format but in this case, the answer term is not found at the end of the question but in the beginning or middle. In Fig 2: Addition of 2 numbers with answer term in the beginning, the Answer Term is not located at the very end of the question but is placed at the start of the question template.

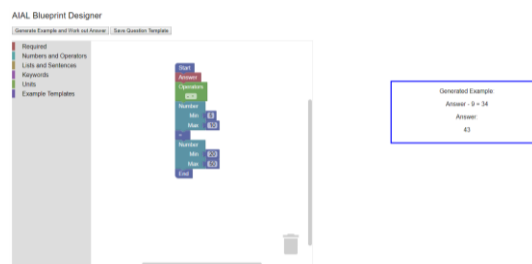


Figure 2: Addition of 2 numbers with answer term in the beginning

The question templates shown in Fig.1 and Fig 2 work similarly for Addition, Subtraction, Multiplication and Division.

Another common question template contains the manipulation (sum, difference, product or division) of 3 numbers. Similarly to the previous question template (Fig. 2), the answer term can be placed at the end, at the beginning or in the middle of the question template.

Other question templates can contain keywords or units such as Count Up (Fig. 3), Descending Order (Fig. 4) and Comparison of 2 numbers with units (Fig. 5)

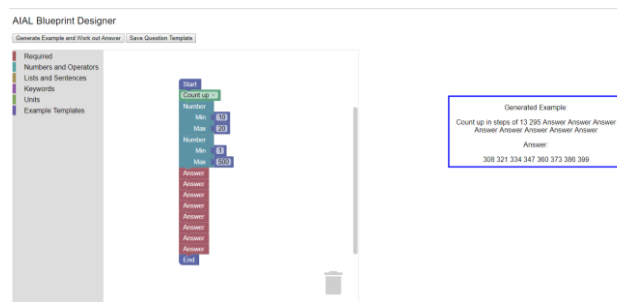


Figure 3: Count Up

Fig. 3 shows a question template in which counting upwards is tested. The question template asks for the next 8 numbers in the sequence starting from 295 and counting up in steps of 13.

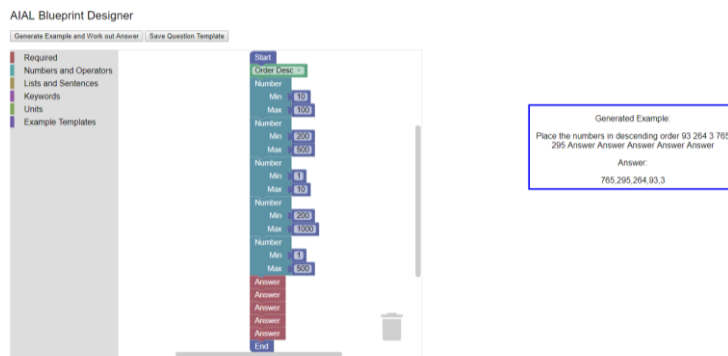


Figure 4: Descending Order

Fig. 4 is a question template in which the order of the 5 numbers must be arranged so that the numbers are in descending order.

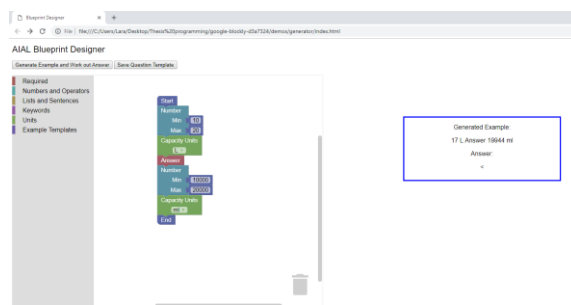


Figure 5: Comparison of 2 numbers with units

In Fig. 5, 2 numbers with units of the same unit category (e.g. capacity) are given and the operator (>, < or =) that fits in between them must be worked out.

A similar question template can be created with numbers only (no units) in order to create questions which test the relationship of one number in comparison to another number.

Another question template type is one which contains lists and/or sentence terms.

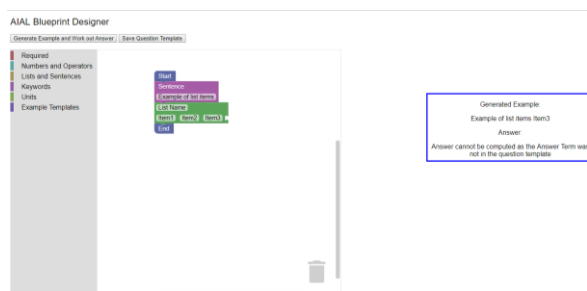


Figure 6: Lists and Sentences

Fig. 6 shows a question template which contains the sentence “Example of list items” and the list named “List Name” which contains the items “Item1”, “Item2” and “Item3”. An answer term is not included and therefore no answer is computed. This will be explained further in the Results section.

3.4.2 Word Problems

There are 2 main types of word/story problems: multiplication word problems or division word problems. Word problems need to start with “MUL|” or “DIV|” to indicate their type. The difference between the multiplication word problems and division word problems is the way the answer is computed.



Figure 7: Multiplication Word Problem

Fig. 7 shows an example of a multiplication word problem which also contains sentences and lists. A word/story problem is more complex than an arithmetic problem and therefore usually requires sentence terms to aid the student to understand the question.

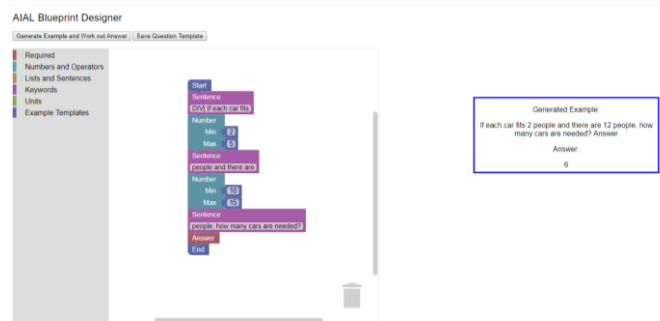


Figure 8: Division Word Problem

Fig. 8 shows a question template of a division word problem. In most cases in division word problems, the smaller number is divided by the larger number in order to compute the answer required.

4 RESULTS

Since the Blueprint Designer forms part of the AIAL application which is still under development, the evaluation and testing stages have not yet been completed.

Once the entire app is ready, primary school students will be given a paper and pencil test on a mathematics topic. The students will then be split into 4 different test groups:

1. Students who will not use the app (control group)
2. Students who will use the app for classwork
3. Students who will use the app for homework
4. Students who will use the app for both classwork and homework

The students will use the app as indicated by the conditions of their test group.

A second paper and pencil test will then be given to the students to evaluate whether using the AIAL application resulted in any improvement in the second test results. This evaluation method is similar to the ones used by Adesina (2014) and Outhwaite (2017) [9, 15].

At the current stage, the following evaluation was carried out to ensure that the Blueprint Designer is working as expected and the answer/s to the examples being generated are being correctly calculated.

Fig. 9 and Fig. 10 show two different examples generated from basic arithmetic problem question templates.

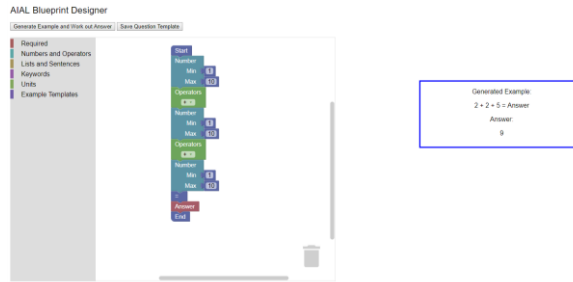


Figure 9: Basic Arithmetic Problem

The answer to the generated example (2+2+5) is 9 (Fig. 9). The answer term is at the end of the question so the sum is computed by adding up the 3 numbers on the left hand side of the equation. Thus, one can note that the Blueprint designer has correctly interpreted the question template and computed the correct answer.



Figure 10: Basic Arithmetic Problem with Answer Term not at the end

The answer to the generated example (3 x Answer = 12) is 4 (Fig. 10) The answer term is not found at the end of the question so the answer is computed by using the inverse operator to the one found in the question. 12 is divided by 3 in order to get 4.

The inverse operator of multiplication is division and the opposite applies. Moreover, the inverse operator of addition is subtraction and the opposite also applies.

The following two figures (Fig. 11 and Fig. 12) are multiplication and division word problems:

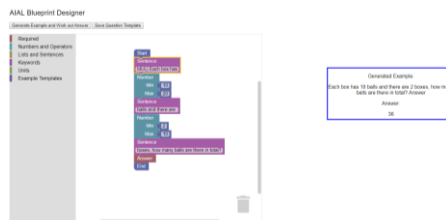


Figure 11: Multiplication Word Problem 2

The answer of a multiplication word problem (36) is calculated by multiplying the two number terms in the question together (18 x 2).

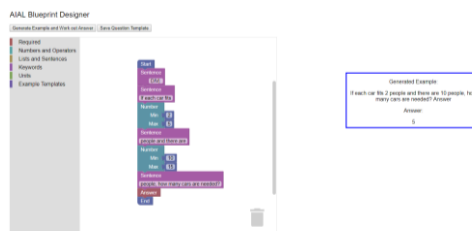


Figure 12: Division Word Problem 2

The answer of a division word problem (5) is calculated by dividing the larger of the two numbers by the smaller number found in the question (100 / 20).

The following figure shows a case in which no answer term was included into the question template. In this situation and similar situations, the answer cannot be computed and the user is informed accordingly.

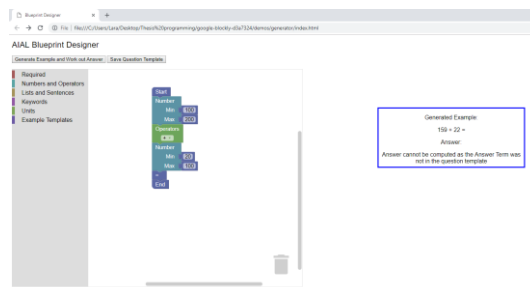


Figure 13: No Answer Term Included

When the answer term is not included in the question template, the generated example will not include an answer term which results in the user viewing a message saying that the answer cannot be computed as shown in Fig. 13.

The following figure shows a generated example for which multiple answers need to be computed:

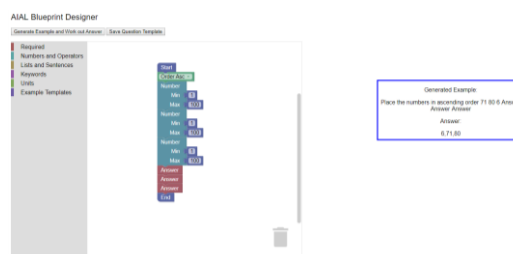


Figure 14: Multiple Answers

In Fig. 14, three answers need to be computed as the template includes three numbers which need to be placed in ascending order. The Blueprint Designer correctly recognizes the numbers (71,80,6) and sorts them into ascending order and then assigns them to the answer terms(6,71,80). A validation check is done in the background to ensure that the number of number terms and answer terms placed into the question template are equal. If this is not the case then similarly to the previous example, the answer/s will not be computed.

5 CONCLUSIONS

The concept behind the Blueprint Designer was to create an easy to use system which will be an important tool for teachers. By using the Blueprint Designer teachers can easily create the mathematics question templates from which questions to be given to their students are generated. Many different question templates can be created by dragging and dropping terms to create a question template. The Blueprint Designer draws inspiration from a visual programming language and this allows teachers with basic or no prior programming skills to use this tool.

The Blueprint Designer forms part of the Artificial Intelligence Assisted Learning (AIAL) application. Through this application the teacher simply instructs the system which specific topics or questions they would like to assign as classwork/homework to the students. The AIAL system then creates the worksheet by generating questions based on the question templates created in the Blueprint Designer. The AIAL system decides the number of questions and type of questions to give each particular student, depending on the student's individual user profile. Thus, work assigned is more stimulating and challenging compared to traditional classwork/homework exercises and the teacher is relieved from carrying out repetitive tasks such as creating worksheets and correcting the work assigned. The teacher will then have more time to focus on specific problems that arise, such as a student struggling with a particular topic. It is for this reason that the Blueprint Designer is thought to be an important tool for teachers to use.

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