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Tarsia Puzzle: An Interactive Activity for the Middle School Mathematics Classroom

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Table of Contents

Abstract

Tarsia Formulator is a software package that enables teachers to create and customize engaging mathematical jigsaw puzzles to fit into their instruction. From arithmetic to calculus content, students have engaged in learning mathematics using this instructional practice. The goal of the activity is to assemble the puzzle so that a particular shape will be formed. Teachers design the puzzle to support specific learning objectives and student's problem solve to match questions and answers which appear on different cards. This Curriculum Project presents Tarsia Puzzles designed to support the instruction and learning of middle school mathematics.

Introduction to Tarsia Puzzles

Tarsia Formulator is a puzzle generating software, created by Hermitech Laboratory, with a free license from http://www.mmlsoft.com/index.php/products/tarsia. The software requires Windows 2000, XP, Vista, Windows 7, Windows 8, or Windows 10 to be installed. The software was originally created to support mathematics teachers and has been used from Arithmetic to Calculus. Teachers from primary to university level use Tarsia puzzles, particularly in the United Kingdom and International Schools across the world. Teachers from a range of disciplines now apply this successful learning tool in their classrooms. There are many online software options that enable teachers to customize their own puzzles, quizzes, or games, but Tarsia Puzzles are unique because it empowers the teacher to create their own customized puzzles that address the specific learning standards and objectives.

Teachers can design customized jigsaws to fit into their teaching objectives. Tarsia Puzzles enables teachers to create a puzzle that requires students to match the pieces together. The goal of the activity is to assemble the puzzle so that a particular shape will be formed. Participants need to solve the question and match the answers which appear on another card. Tarsia Formulator includes a robust equation editor for building mathematical expressions for the activities and provides powerful instructional support for learning activities since it supports the activity templates. With this software, teachers can create, save, print, and exchange customized jigsaws, domino activities and a variety of rectangular card sort activities. The activities created using this software can be presented in printable form, ready to cut and use (Hermitech Laboratory, 2003).

The key to success in devising an effective puzzle and the achievement of learning is closely related to the clarity and simplicity of the questions and answers used. Care should be taken at this stage to check any error that can appear in the final puzzle. The shape and size of the puzzle determines the number of questions (and answers) to be inputted. Samples of puzzle

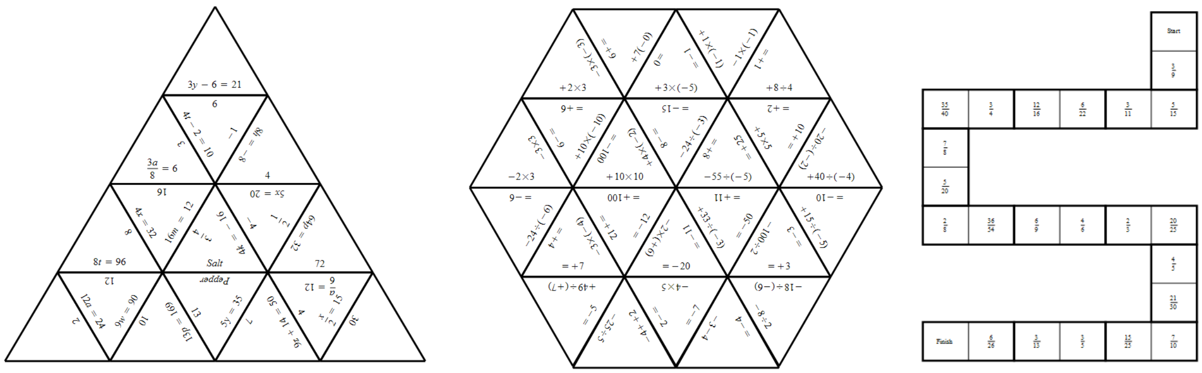

Figure 1. *Sample of puzzle and domino activities*

and domino activities can be seen in Figure 1. There are a variety of possible puzzle shapes available. For instance, a tortoise shell shape (see Figure 7) takes 12 assorted shapes including triangles and squares, whereas a triangle shape takes 16 triangles while a large hexagon includes 32 triangles. A variety of puzzles can be designed by teachers based on the content to be taught. Figure 2 shows the range of shapes available in Tarsia puzzles while Figure 3 shows a triangular

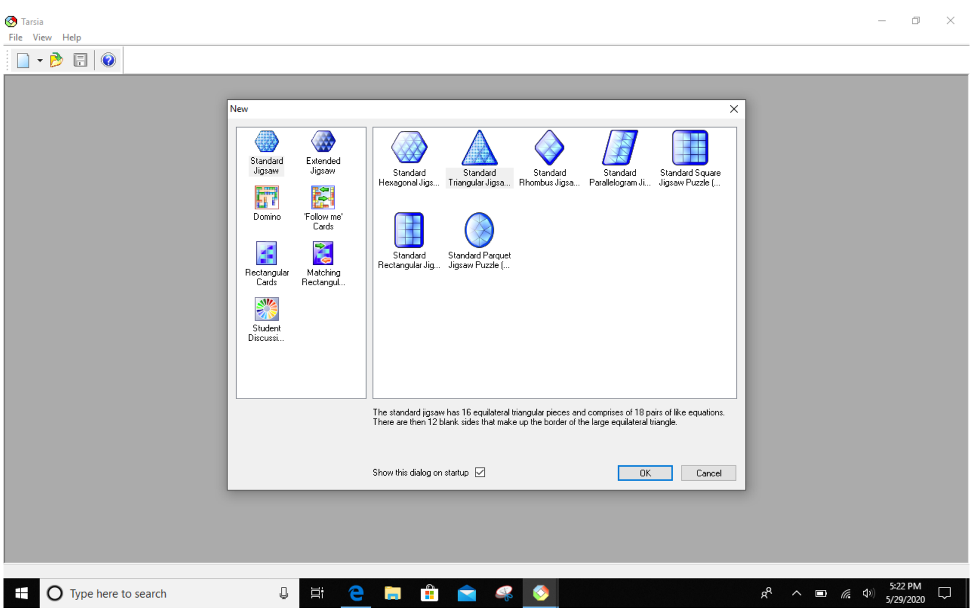

Figure 2. *The range of Tarsia puzzle shapes available.*

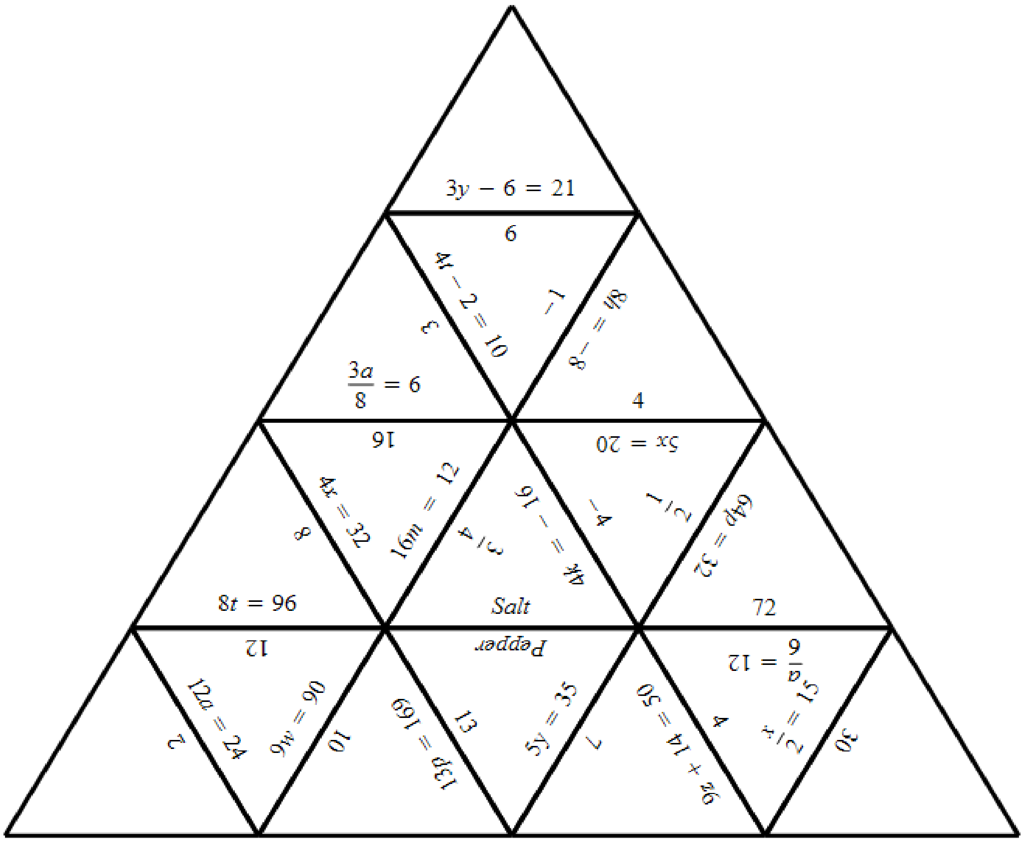

Figure 3: *An example of a completed 16-domino Tarsia puzzle on Two-step equation.*

puzzle. A guide on how to create a Tarsia puzzle is presented in the appendix. Tarsia puzzles can be created for any mathematical content. The puzzles provide questions (and answers) much like a worksheet but in the form of a puzzle. Both questions and answers are inputted by the teacher into the software in a matching pattern. For example, when introducing word problems in grade 7, relevant terms such as "sum, difference, total, product, quotients" can be linked to a similar vocabulary like "sum" will be paired up with "to add". "Product" is talking about "multiplication", "double" means "times 2", "half" means "divided by two".

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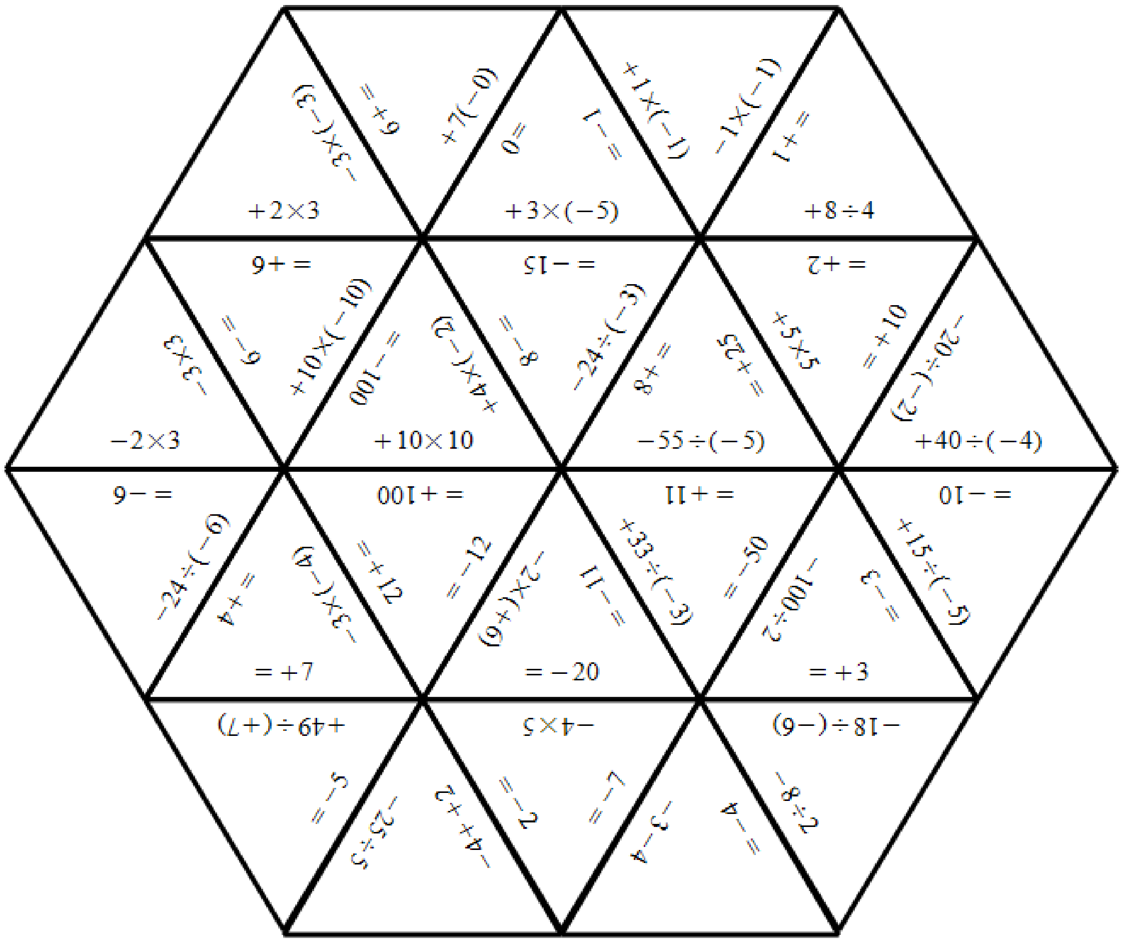

Figure 4: *A completed 24-domino Tarsia puzzle on simplifying integers.*

Another example in solving one-step equations, “4x = 12” will be matched with “x = 3”. Another example of a completed Tarsia puzzle is presented in Figure 4. Specific directions of how to create your own Tarsia Puzzles are presented in the Appendix.

Review of Literature

Since antiquity, people of all ages have found pleasure in puzzles, and for many today, the appeal of puzzles is still irresistible. There is a lot of literature on the use of puzzles in the classroom. Every conceivable objective can connect to puzzles; from thought-provoking recreation to a means of improving attitude. Michalewicz (2008) said, puzzle material, properly related to classwork can be a valuable aid to teaching. Most of us have a “puzzle instinct” and that the puzzle question at the right time and place will not only make a class more interesting but can further the learning of mathematics.

There has been very little research done into the benefits of Tarsia puzzles in the Mathematics classroom. What research exists has been written by government agencies in England or schoolteachers in International schools from a practical perspective on how to deliver Tarsia in the classroom. However, there is research on how Tarsia can foster collaboration in the mathematics classroom.

Collaborative Learning

Solving Tarsia puzzles can improve collaborative learning in the classroom (ChingHao & Azlina, 2019) and support the generation of new knowledge (Laal & Ghodsi, 2012). ChingHao and Azlina (2019) proposed the incorporation of Tarsia puzzles as a means to induce collaboration and communication among students while maintaining the amount of practice and work which they want their students to have. These authors found that students perceived Tarsia Puzzles as an effective tool to improve the collaborative learning process in the classroom. In a cooperative learning setting, students are actively involved in the learning process and more likely to become interested in learning and participating in school (Laal & Ghodsi, 2012). Students also developed leadership and trust-building through Tarsia Puzzle activities. Although there was no instruction about team leaders, in each group someone naturally take on the role of a leader. Tarsia Puzzles enabled students to feel like they were part of a team as they collaborated, exchanged ideas, and came to an agreement with other group members effectively. Qomaria (2017) focused on Grade 8 students learning mathematics and established that students engaged in Tarsia Puzzles generated effective dialogue around checking answers and finding puzzle positions. It was observed that students enjoyed the Tarsia Puzzles activities and they worked well together in small groups.

Problem Solving and Transfer of Learning

Vygotsky (1978) stated that students learn best through interaction with peers, teachers, and manipulative tools. Teachers function as facilitators to guide learning and not to be the main contributors. In addition, Vygotsky stated that students need to be guided by adults but also have the opportunity to be influenced by their peers. This interaction with peers may expose students to a variety of prior experiences and spark cognitive conflict that can lead to discussion and the construction of knowledge (1978). Interactions with teachers also foster the construction of knowledge when they act as a guide to learning within the zone of proximal development. This zone is understood as teaching not what students already know, and not what they cannot yet do, but within the space where students can learn new content when guided by a knowledgeable person. This could be a teacher, peers, or other expert in the content being learned. Tarsia Puzzles enable students to connect prior knowledge with the construction of new content, which is known to support the transfer of learning. For mathematical understanding to transfer, concepts being learned must connect to prior knowledge to support the processing of new mathematical material (Wade, 2011). One of the striking findings of ChingHao and Azlina (2019) Tarsia Puzzle research was that students lost track of time when problem solving with Tarsia Puzzles. That is, as defined by Csikszentmihalyi (1990), the students entered the state of flow, a hyper-focus state experienced by those who are fully engaged with their work. Additionally, Qomaria (2017) observed that students utilized different strategies to solve the Tarsia Puzzle. If one strategy did not work, they persisted in trying a different strategy. Choosing the best strategy for their group was an experience to improve their decision-making skills.

Use in the Classroom

Tarsia Puzzles have been used in International Baccalaureate (IB) schools and International schools abroad especially in the UK. I first discovered the use of Tarsia Puzzles in the classroom in one of my IB professional development (PD) courses in Brussels. It was introduced as an ice breaker by the facilitator. The topic was rationalizing denominators. The finished product formed a hexagon. From that PD, I did more research on Tarsia Puzzles and started using them actively in my classroom.

First, I used Tarsia Puzzles to consolidate student's understanding of the subject content. For example, after teaching one-step equations and before moving on to two-step equation, a Tarsia puzzle was used as a warm-up before the new topic began (see figure 5). I also used Tarsia Puzzles as part of a station activity (see figure 6), where students completed the puzzle under a certain time frame before moving on to the next station. This practice aligned with Kolb's (1984) model of learning theory. The first stage of the activity required students to engage in testing hypotheses about possible logical links. Afterwards, students were able to analyze what they did or did not know.

Second, Tarsia puzzles provided an excellent tool to promote collaborative learning in small groups. In my years of teaching middle high school mathematics, I have found that students were more engaged in their learning when they were working collaboratively with each other. I learned it was more effective to use Tarsia Puzzles with small groups of two or three students. This size of group tended to maximize participation and commitment among its members. Tarsia Puzzles promoted collaborative learning where students were able to contribute to the learning activity. As such, Tarsia Puzzles were an effective tool to promote group identity. Students had the opportunity to develop leadership, decision making, trust-building, communication, and conflict-management skills while working with Tarsia Puzzles. Such experiences typically result in greater productivity, increased performance, and higher self-esteem.

Third, Tarsia Puzzles created a competitive environment in the classroom. Students found this enjoyable and I found learning was enhanced. On game day I used Tarsia Puzzles as one of the options in a Jeopardy game and instead of using the most difficult round in Jeopardy, I replaced used the completion of a Tarsia Puzzle. Students enjoyed the challenge of a fast-paced activity, particularly if there is a competitive context to the activity.

Fourth, Tarsia was used as a differentiation tool. Tarsia Puzzles allowed me to vary the difficulty of the puzzles to meet the differing learning needs of students. For example, Figure 7 shows a differentiated one-step equation Tarsia puzzles. The one on the left is a 16-domino puzzle while the one on the right is a 12-domino puzzle. It is also possible to differentiate according to ability by allocating different puzzles to specific groups of students. For example, one group could be working on a two-step equation, another could be working on a multi-step equation and a third group could be working on complex multi-step equations with fractions.

Finally, Tarsia Puzzles were used to recap previous learning, as a warm- up, as extra practice for individuals or team members, and as a tool to increase mastery for students who were falling behind. Tarsia Puzzles provided spiraling curriculum activities. Also, students preferred Tarsia Puzzles to the traditional question and answer worksheets.

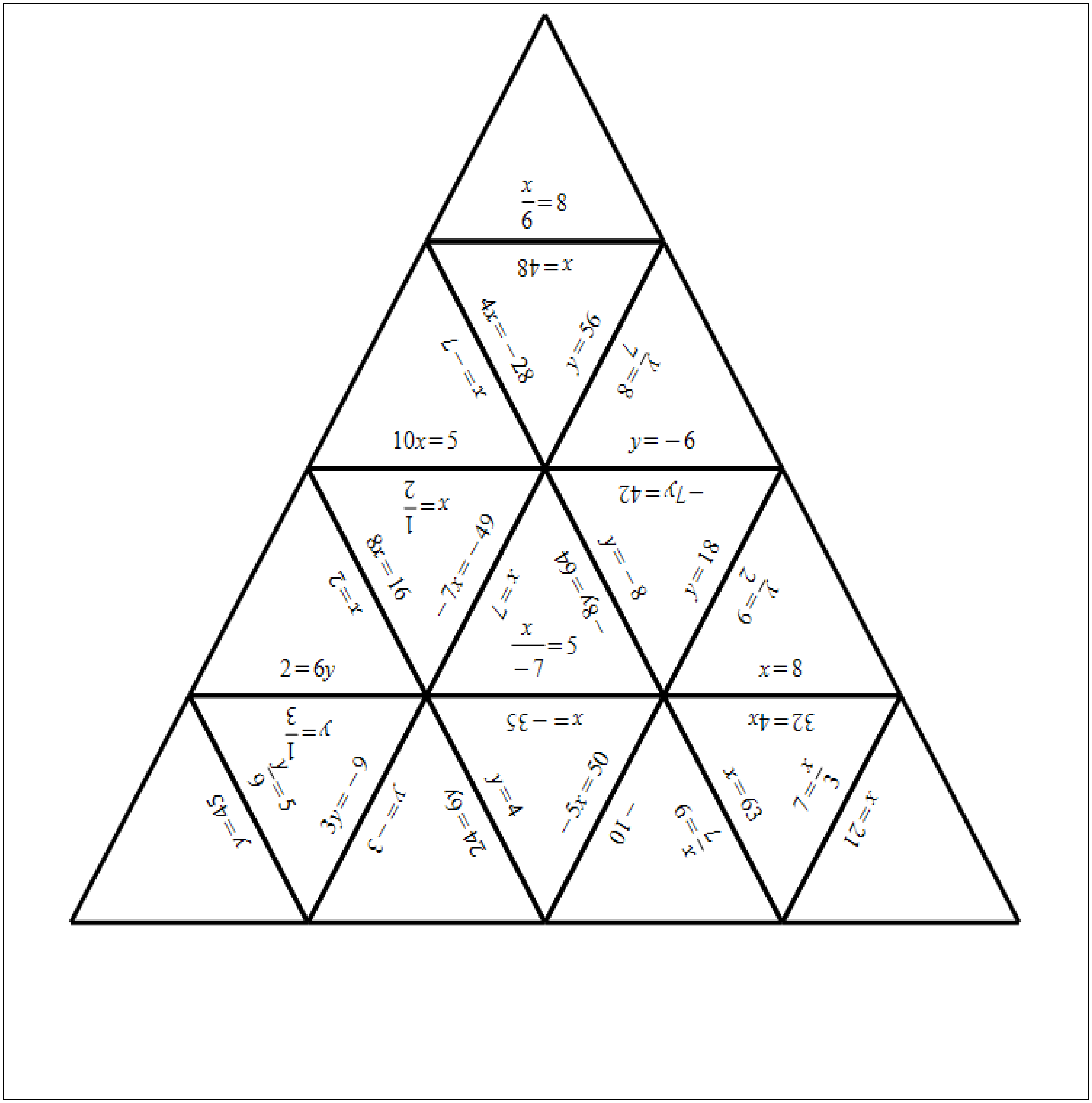

Figure 5. One-Step Equation Tarsia Puzzles.

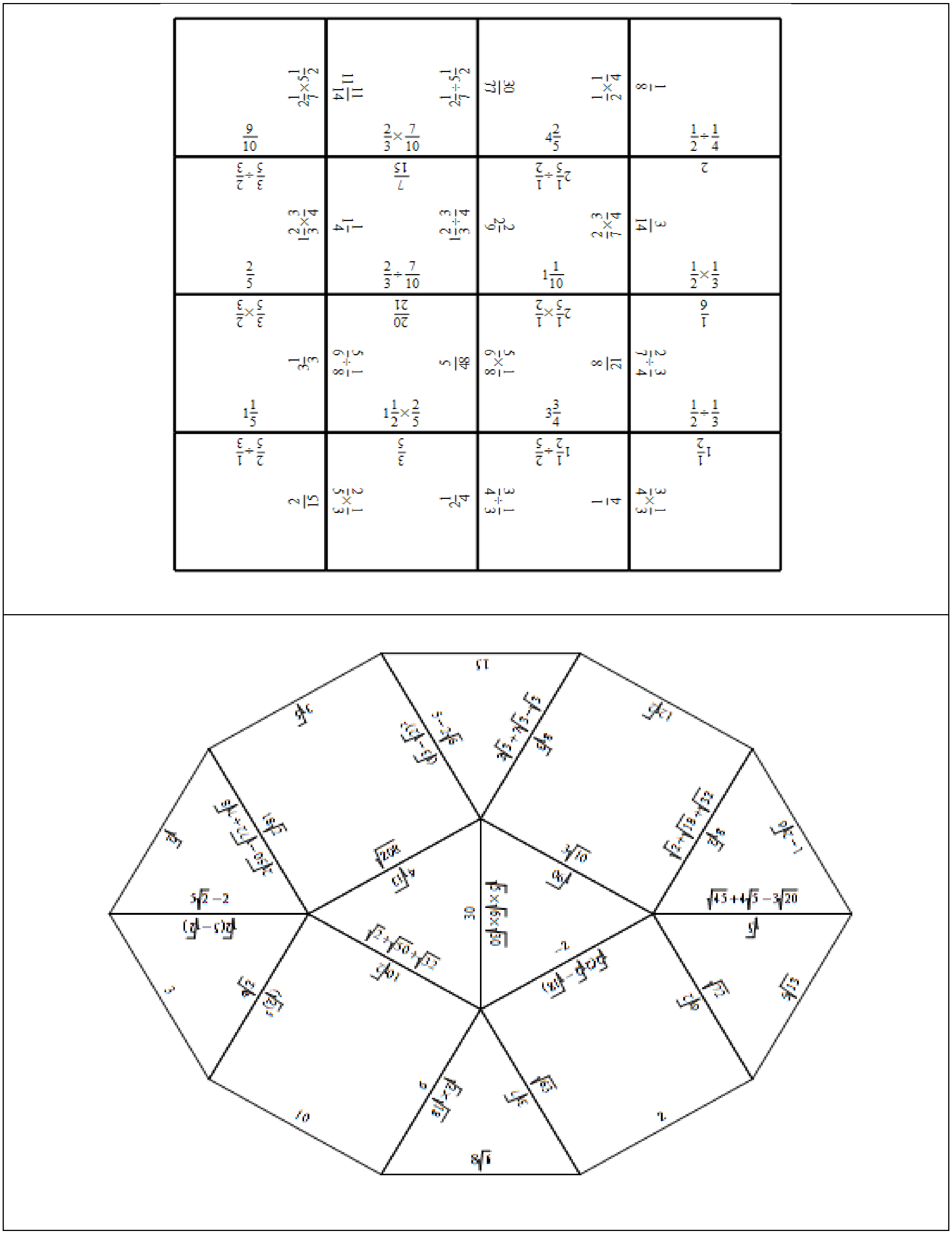

Figure 6. Sample Tarsia Puzzles for Station activities

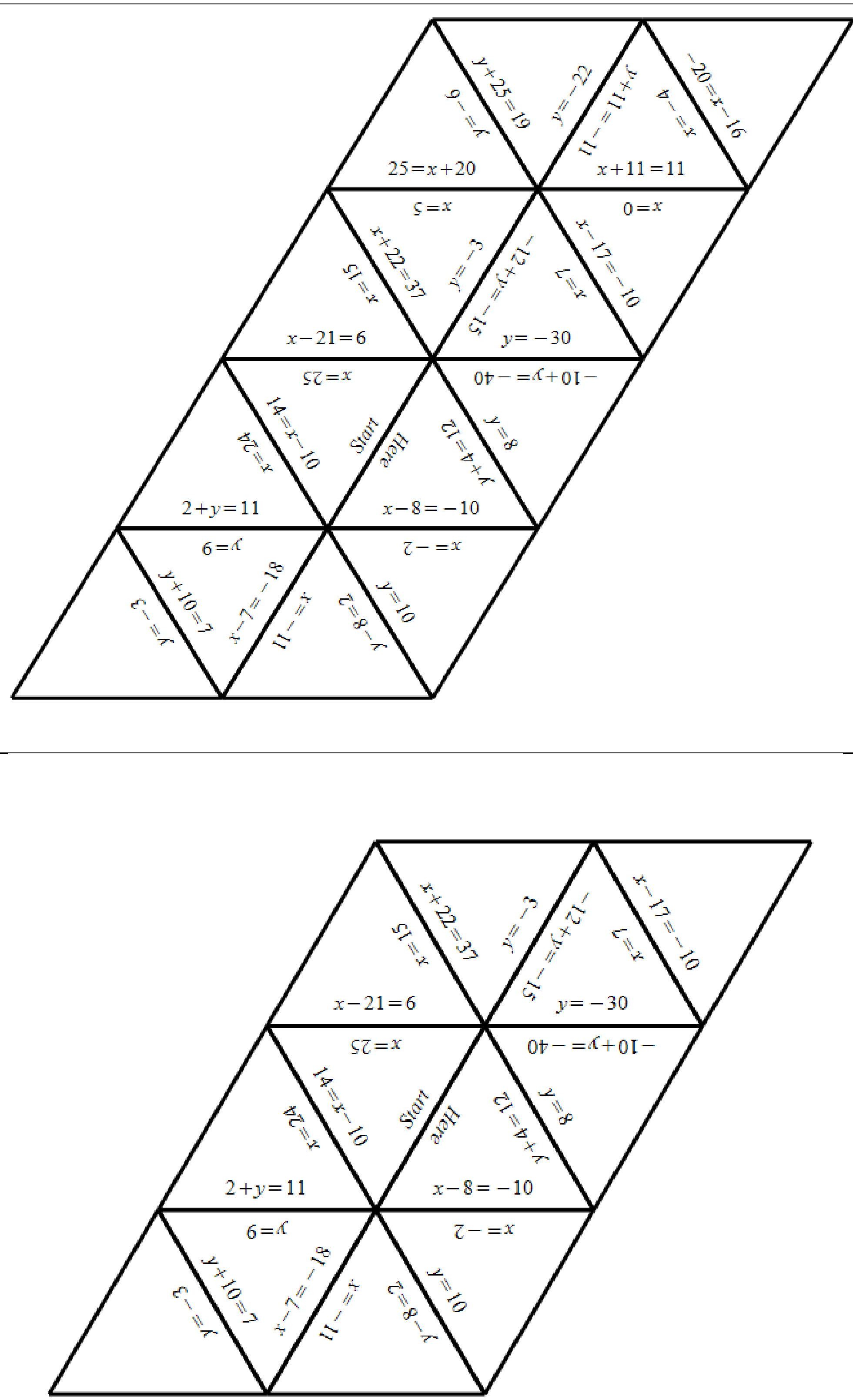

Figure 7. Differentiated On-Step Equation Tarsia Puzzles.

Analysis and Conclusion

This curriculum project was developed from the author's experiences of using Tarsia Puzzles in the middle school mathematics classroom. Tarsia Puzzle were found to be an instructional practice that consolidated learning, provided collaborative and competitive learning activities. They also allowed differentiation of instruction and the spiraling of the curriculum. It is my hope that other teachers will try Tarsia Puzzles and incorporate them in their instructional practices.

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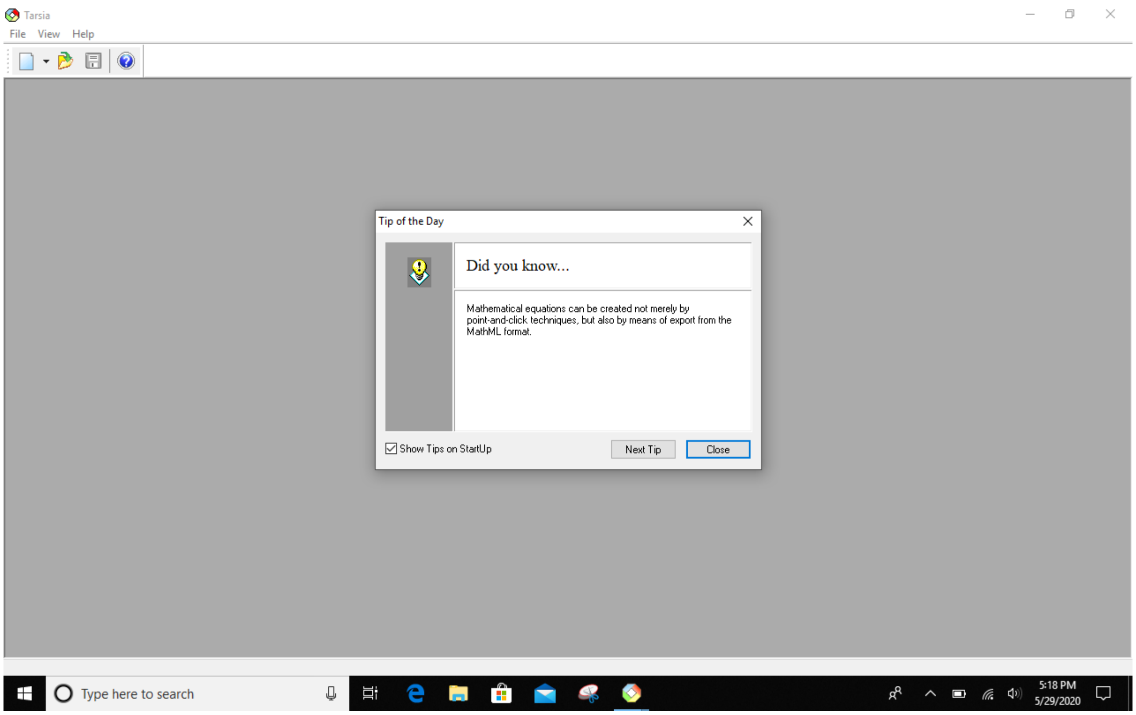
Appendix

Instructions on how to make a Tarsia Puzzle

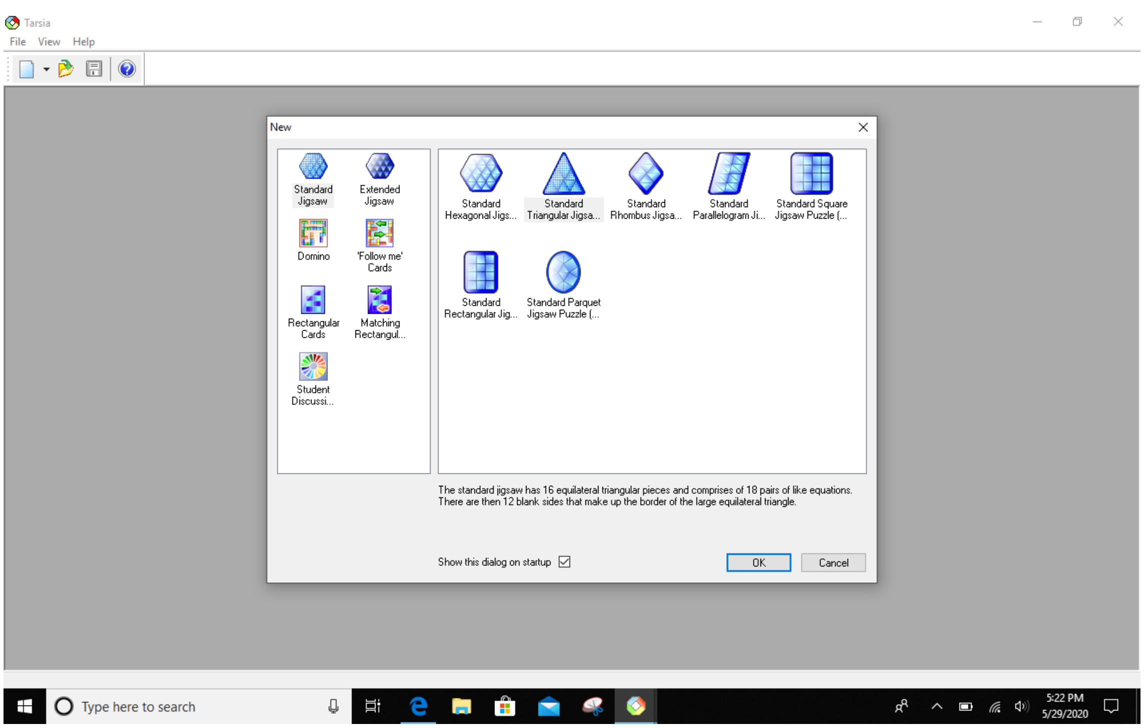
Consideration should be given to the level of difficulty and differentiation desired as the complexity and challenge of the exercise is linked to the shape and number of "dominoes" used. Once printed, each sheet paper or card should be laminated. This will extend the longevity of the materials so that they can be used again in another class or the following year. Each "domino"- and these can be in the form of a triangle or a square- from the printout should be cut out and placed in a bag, with a label to distinguish it from others. It could also be printed in different colored papers and collated with a rubber band. It is important that its bag or pack should have the correct number of dominoes to complete the puzzle. Care should be taken to check the composition of the bag or pack prior to the lesson.

Teachers are advised to refer to Hermitech Laboratory website (http://www.mmlsoft.com/index.php/products/tarsia) for detailed guidance of the range of functions available.

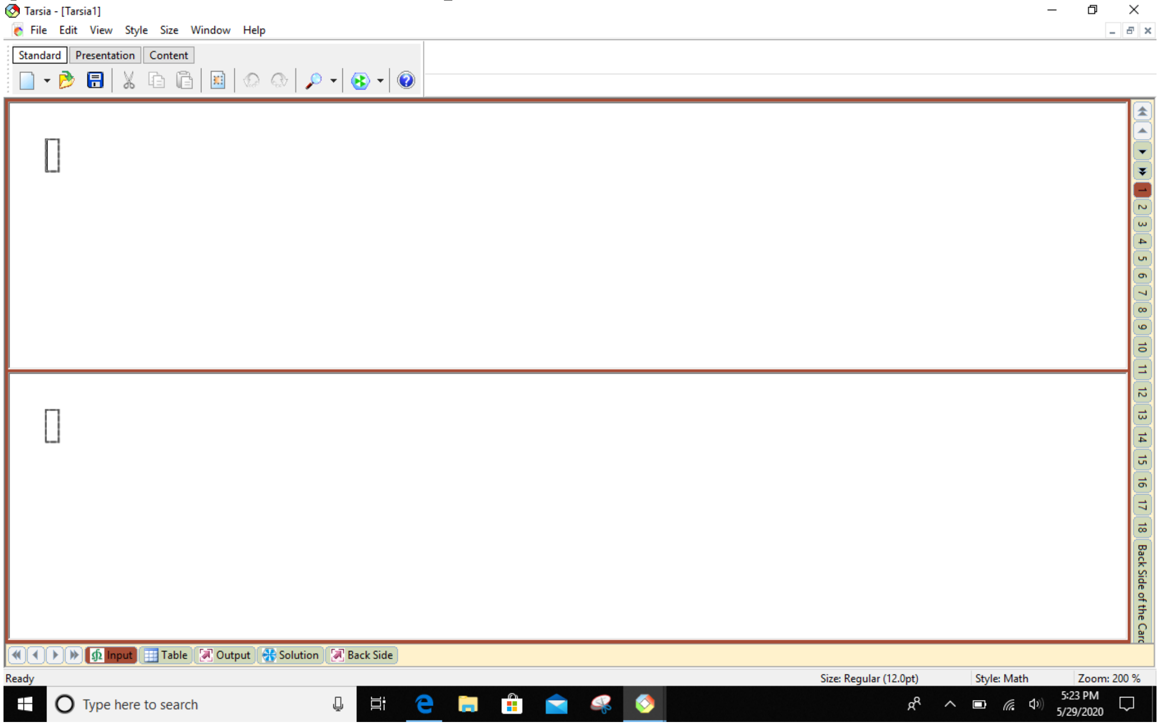
First page – If you would like a tip or get on with using Tarsia.



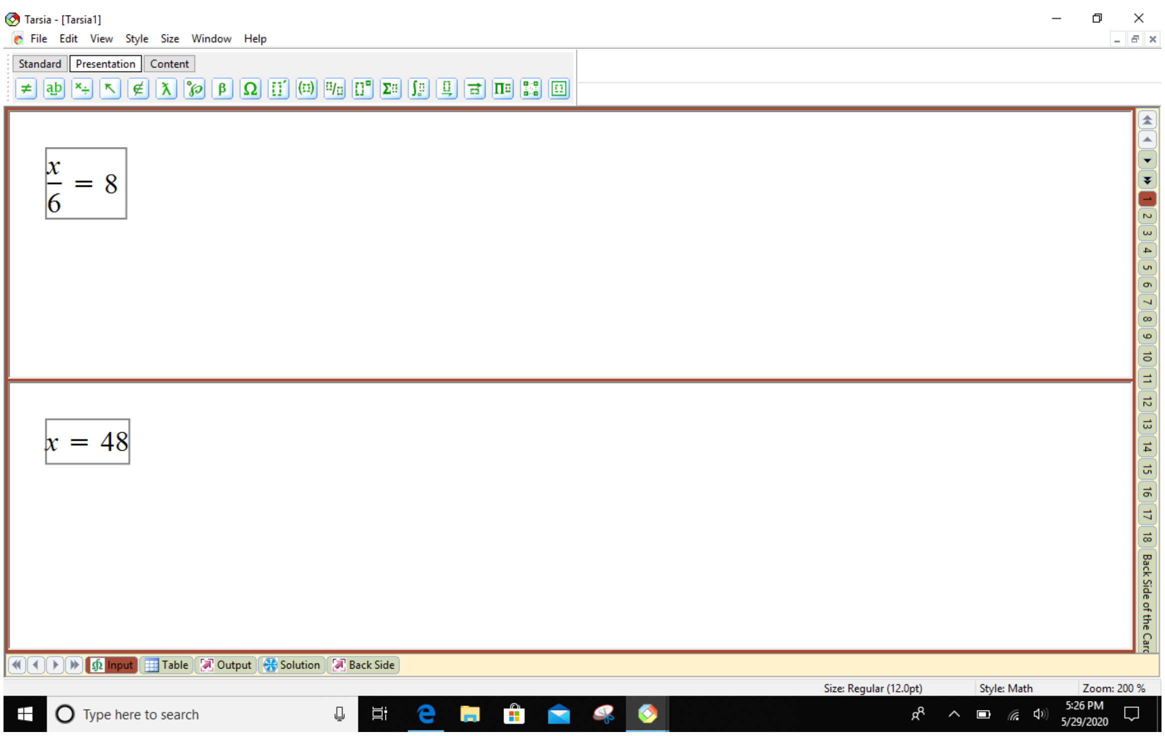
Second page – Decide which shape you would like to generate for the puzzle and click on it.



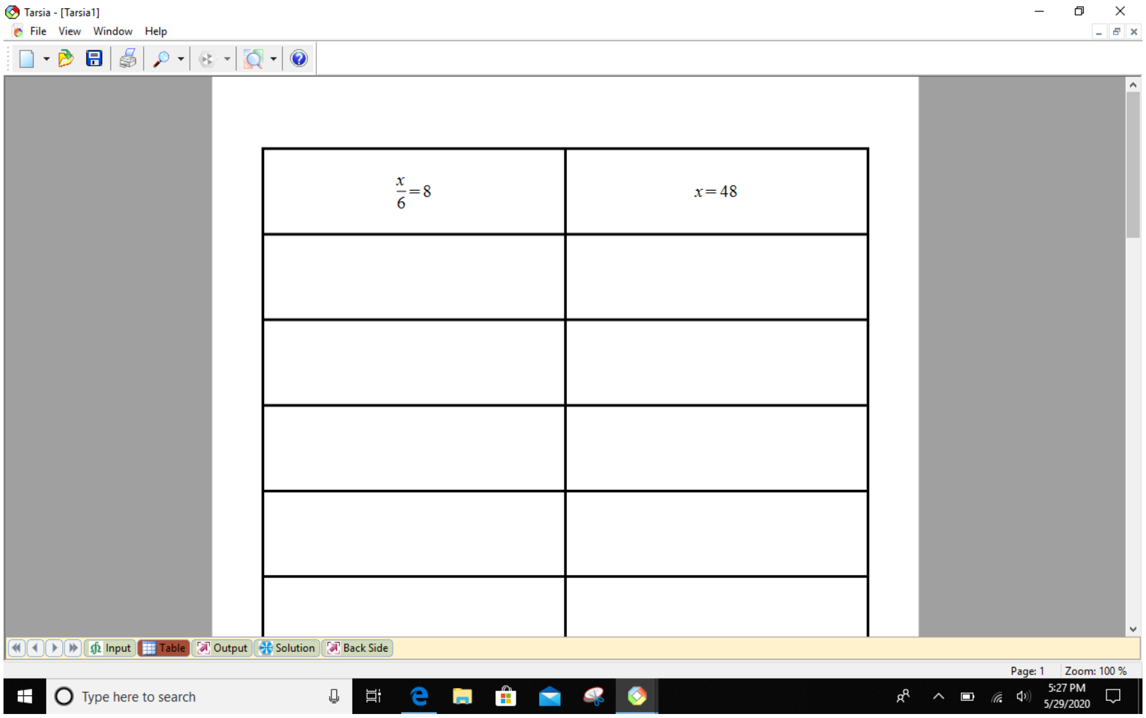
Third page – Say you clicked on the triangle icon; you would see the screen below. Type a question and an answer into the spaces.



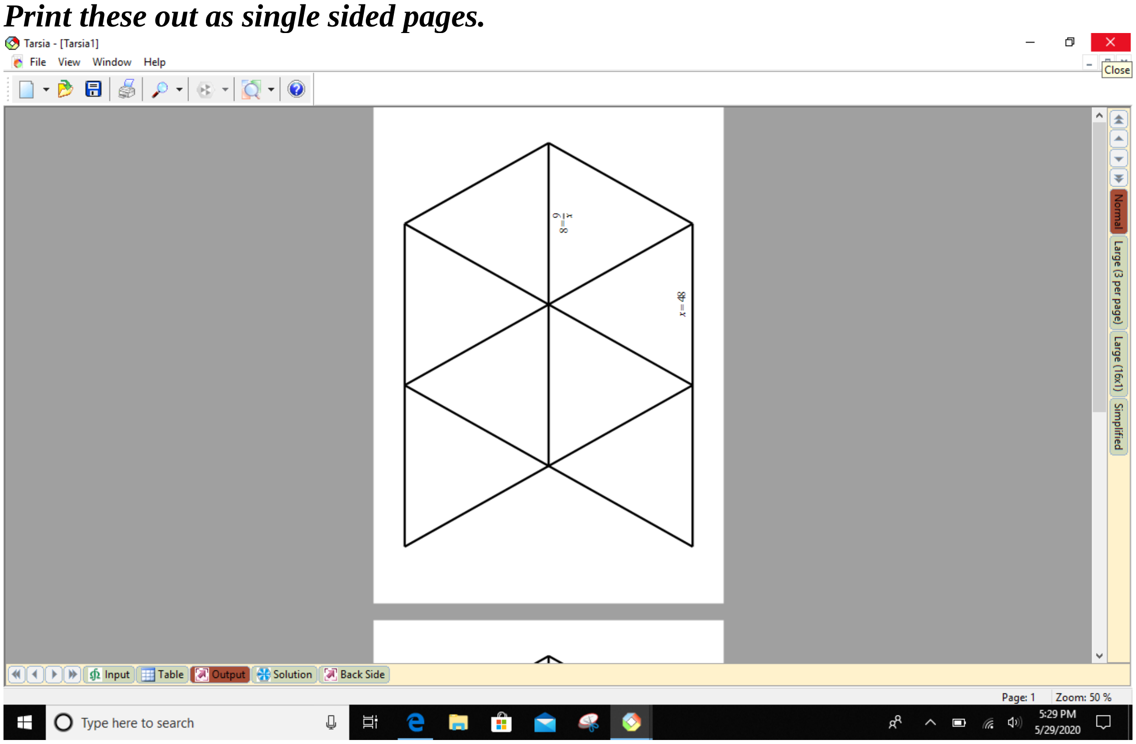
Fourth page – See the inputs.



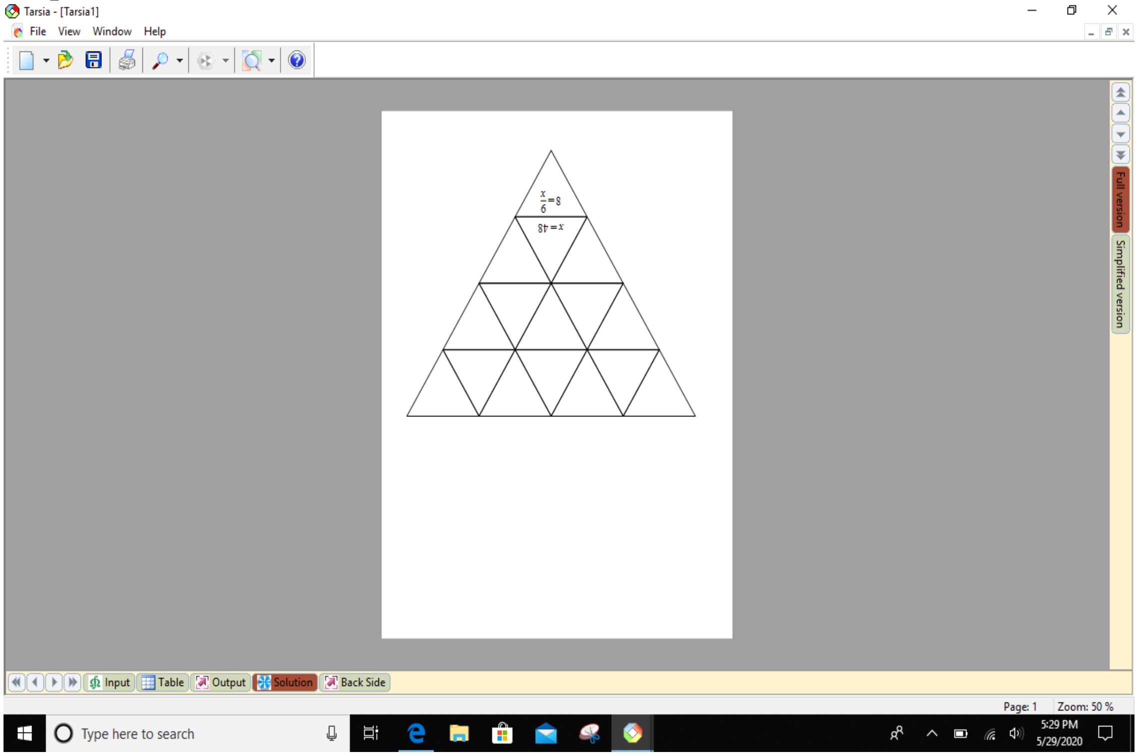
Fifth page – Once you have input all your prompts, double check on the table icon at the bottom of the screen. Check spelling, signs, formatting at this stage. Click on inputs to correct errors.



Sixth page – Once you have finished inputting, click on the output icon to see the triangles. Print these out as single sided pages.



Seventh page – Click on the solution icon at the bottom of the screen to generate a solution to the puzzle.



Eighth page – Solution of a finished product looks like this.