EasyA: Learning Maths through Dialogue

Dr Parastoo Ghalamchi

EasyA

Author Note

This paper illustrates the theoretical foundation of EasyA, a mobile tutoring application that is designed to encourage problem solving through problem posing in mathematics through dialogue between students and tutors.

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Abstract

EasyA is a maths tutoring mobile application that aims to deepen students' mathematical understanding through dialogue between students and tutors. Tutoring sessions are designed based on Bakhtin's (2010) dialogism, whereby EasyA tutors enter into dialogue with EasyA students. To start the dialogue, students open the EasyA app and take a photo of their question. Students are then connected with a tutor who can help them understand and solve the problem. As soon as the student is connected with the tutor, the student chooses how to conduct their dialogue with the tutor. The student can choose to solve the problem in one of two directions:

- **Problem Solving First, Problem Posing Second**: choosing this direction, students immediately receive the final answer to the problem and then begin a dialogue with EasyA tutors to find their own path to the final answer. EasyA measures the learning success of these sessions based on a "**creativity**" factor. This represents the extent to which the student uses their creativity to find their own path to the final answer provided by the tutor at the beginning of the session.
- **Problem Posing First, Problem Solving Second:** choosing this direction, students start a dialogue with EasyA tutors and work together to find their own solution without receiving the answer at the beginning of the session. EasyA measures the learning success of these sessions based on a "**collaboration**" factor. This represents the extent to which the student and tutor have collaborated to find a solution, rather than the tutor dictating a solution to the student.

EasyA sessions provide students with a dialogue space that extends their mathematical understanding based on the "Art of Problem Posing" by Brown and Walter (2005), meaning in each session tutors support students in two phases:

- **Phase 1) Accepting**: EasyA tutors help students explore (observe, question and hypothesize) the problem. In this phase, students learn the extent to which they know, understand and believe in the assumptions that are inherent to the problem.
- **Phase 2) Challenging**: EasyA tutors help students list the attributes of their assumptions and then challenge them (i.e. "what-if-notting" the attributes) by asking questions and analyzing the problem.

Using EasyA, students become active learners. They enjoy a deep understanding of mathematics and they learn the skill of problem posing through dialogue with EasyA's tutors. This teaches students a highly translatable skill that maps well onto other subject areas.

Keywords: EasyA, Dialogism, Problem Posing, Problem Solving, Mathematics

EasyA: Learning Maths through Dialogue

EasyA is an application of Bakhtin's dialogism for learning maths in a digital space. It is based on "the Art of Problem Posing" (Brown and Walter, 2005), whereby students and tutors communicate through a series of questions and answers. The digital space that EasyA provides for Q&A between students and teachers is a *dialogue space*, an effective environment that encourages students to ask questions in order to deepen their mathematical understanding. With EasyA, when the student receives the answer to their question, learning does NOT end, but instead students start learning from the solution by challenging the assumptions inherent to the problem. When a student asks a tutor a question, the student can choose from one of two directions in which to conduct the session and obtain a deeper understanding of the topic.

- **Direction 1) Problem Solving First, Problem Posing Second**: Once the student posts a problem (i.e. asks a question), they choose to receive the answer immediately and then start exploring the problem to find the solution through dialogue with EasyA's tutors.
- **Direction 2) Problem Posing First, Problem Solving Second**: Once the student posts a problem (i.e. asks a question), they choose NOT to receive the answer immediately, and then start exploring the problem to find the solution through dialogue with EasyA's tutors.

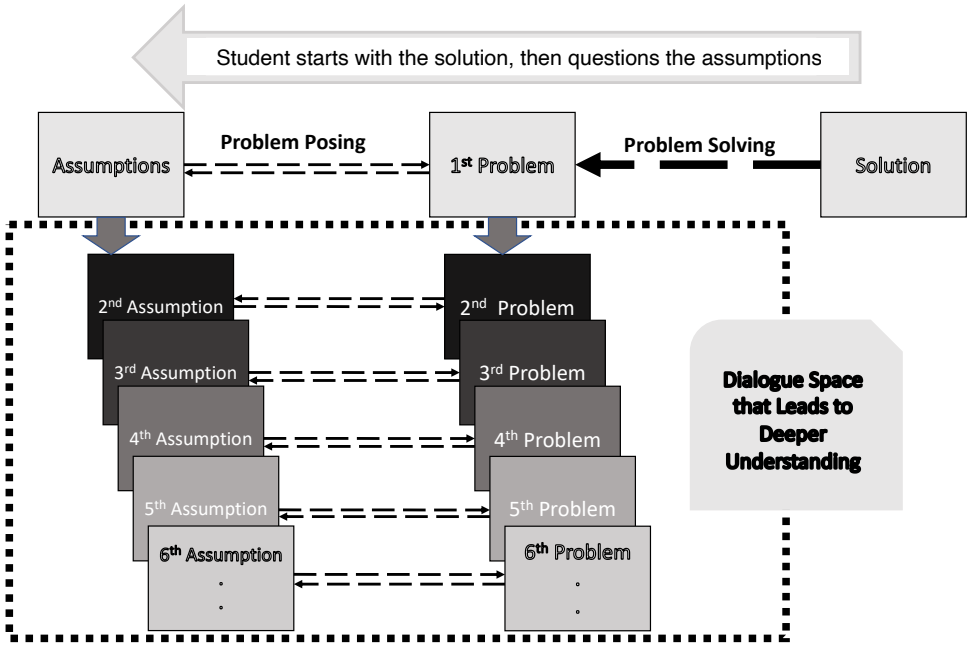
It should be emphasized here that both of these directions lead students to a deeper understanding of the mathematical problem, which is the EasyA learning goal. EasyA is designed to provide an active learning space for students, which is why students have the authority to choose which direction to follow. These methods, including how they lead to a deeper understanding of mathematics, are outlined in the following sections.

Direction 1) Problem Solving First, Problem Posing Second:

- *Problem Solving First:* The session begins with the student receiving the final solution to the question they ask on EasyA.
- *Problem Posing Second*: The session ends with the student delving deeper into the problem and seeing how one might reach the answer. Here, the student achieves a deeper understanding of the mathematical phenomenon through dialogue with EasyA's tutors. Students find their own creative way to the final answer.

If a student chooses this option, the tutor responds immediately with the final solution to the problem and at this point the scaffolding process starts: the tutor encourages the student to start asking questions about the assumptions that led to the solution (Figure 1). In many cases, the difficulty in answering a question lies in the assumptions behind the question itself. This is the problem posing approach, based on Brown and Walter's (2005) "the Art of Problem Posing", that is embedded in EasyA. Brown and Walter claim that after the student solves a problem, they often don't understand the significance of what they have done, until they start generating new problems. Figure 1 illustrates the mechanism of this method. First, the student sees the solution and then EasyA provides them with a dialogue space, by offering a structured questioning process to both students and tutors. This encourages students to pose problems in order to challenge any assumptions, allowing them to achieve a deeper understanding of the problem.

Figure 1. Learning mechanism of "Problem Solving First, Problem Posing Second" in EasyA.

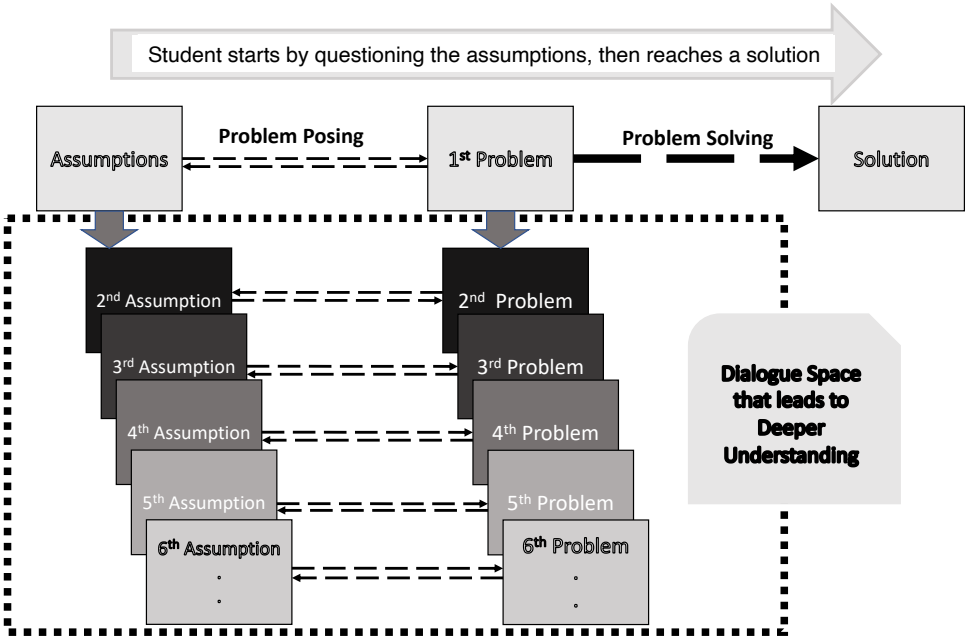


Direction 2) Problem Posing First, Problem Solving Second:

- *Problem Posing First*: The session does NOT start with the student receiving the final answer, but with the student going deep into understanding the problem through dialogue with their tutor. The dialogue process is guided by the problem posing that leads the student to find a solution via collaboration with their tutor.
- *Problem Solving Second*: The session ends with the student arriving at the solution to the problem through their dialogue with the tutor.

If a student wants to solve the problem before receiving the final answer, then they choose this option (Figure 2). All EasyA tutors are trained in the dialogic approach to help the student find the solution through understanding "what this problem is asking" and then to challenge the assumptions by asking "what if I shift my focus from what seems an obvious component of the problem to something that seems remote?". Here, EasyA allows the problem to be reconstructed by the student with help from their tutor. Their tutor poses new problems, and encourages the student to challenge the assumptions behind those problems, until they reach a solution. Figure 2 shows how this process is embedded into EasyA to foster deeper understanding.

Figure 2. Learning mechanism of "Problem Posing First, Problem Solving Second" in EasyA.



Why EasyA Deepens Mathematical Learning

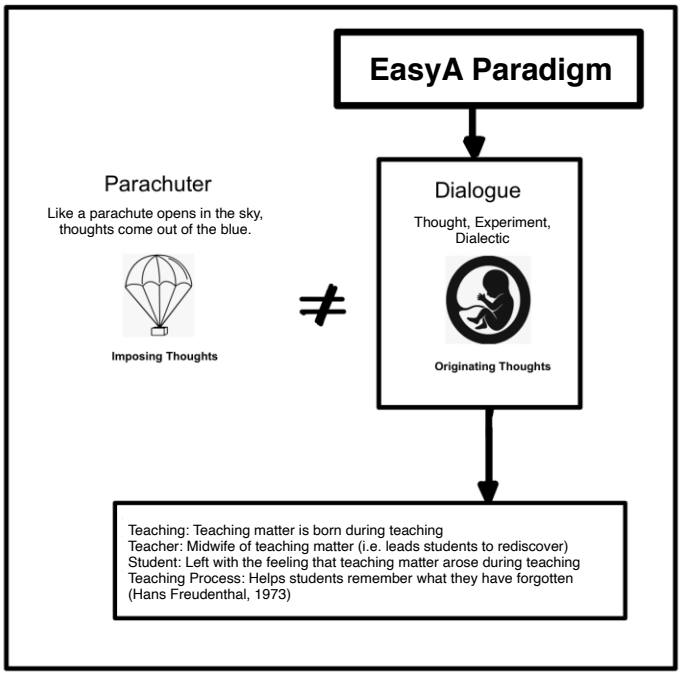
"In ordinary everyday behaviour, in what sense can we examine a talking unless we bring a hearing along with it into account?" (Dewey & Bentley, 1991/1949, p. 127)

The theoretical foundation of EasyA is Bakhtin's (2010) dialogism that enables the platform to create a learning space for students to become active learners, by engaging them in the problem posing process. EasyA provides a space for dialogue, between students and tutors, for mathematical questions using Brown and Walters' (2005) "Art of Problem Posing", which advocates a learning approach through dialogue. Students learn inductively through Q&A with their tutors. From the dialogical perspective, learning is seen as the process of multiple voices coming into contact, both within and across student-produced ideas (Koschmann, 1999). Dialogue is a term used to capture the relational nature of question and answer between student and teacher. Building on Bakhtin dialogism, EasyA lets the voices of students and tutors be heard and woven together to create a deeper understanding of the topic. Within this paradigm, EasyA enables a dynamic tension between the tutor's understanding of the problem (the centripetal) and the student's discovery (the centrifugal) of specific mathematical problems. This is the EasyA dialogue space that enables its students to become active learners, which leads them to deeper mathematical understanding. With EasyA, not only is the student's voice acknowledged, but the student is also encouraged to express their own point of view by asking questions and challenging assumptions. This approach results in deeper learning, because the difficulty in answering a question often lies in the assumptions behind the question itself.

Figure 3 shows how students use EasyA to generate ideas, through the dialogical paradigm inherent to the way EasyA's Q&A-based tutoring sessions are designed. Using EasyA,

students generate ideas through dialogue with their tutor, rather than simply conjuring these ideas up out of the blue, much like a parachute suddenly opens in the sky. With EasyA, teaching matter is created during each tutoring session with student and tutor. The EasyA tutor can be thought of as the midwife of teaching matter, responsible for leading their student to rediscover the assumptions inherent to the problem and challenging them by posing new problems as they try to find a solution. As a result, the students are left with the feeling that teaching matter arose during each session, which is an application of Freudenthal's (1973) view on learning mathematics, which emphasizes helping students to remember what they have forgotten through question and answer.

Figure 3: Dialogical approach of EasyA versus the parachute approach.



Four Learning Outcomes of EasyA

Students who use EasyA do not only receiving a real-time solution to their mathematical problems, but they also learn four significant learning skills that are translatable to other subject areas. The following are four outcomes of the dialogical approach that is embedded in EasyA:

1. **Becoming Active Learners**: EasyA encourages the general attitude of "coming to know", by modifying the things students want to know (Dewey, 1986). Since the EasyA learning environment is designed based on Bakhtin's (2010) dialogism, students have the autonomy to ask questions and challenge assumptions. Hence, they become active learners as they start to appreciate and understand the problem by actively challenging the assumptions inherent in the problem. Further, due to the real-time nature of EasyA, the student is completely in control of when they want to learn. The student doesn't have to wait to schedule a tutoring session, leading to a better learning outcome as the question is still fresh in their mind.
2. **Experiencing Authority in the Learning Process**: EasyA provides a dialogue space, where students experience authority to question any assumptions. This is a key differentiator between EasyA's Q&A-based tutoring process and other online tutoring applications. With EasyA, both students and tutors have the authority to question the assumptions and to ask "what-if-not". This experience has a transformational impact on the student's attitude towards learning mathematics, and the student develops an inquisitive approach to learning that is translatable to other subjects. Tulwin (1977) notes, asking questions and posing problems is a much more significant task than we usually believe, showing that how disciplines are divided is based on the questions they ask not the content. Hence, students

who use EasyA experience the authority to challenge mathematical assumptions and can use this newfound authority in the other subjects they might be studying.

3. **Reaching a Deep Understanding of Mathematics**: EasyA provides students with a space where they can view the question in a sharper light and acquire a deeper understanding by entering into dialogue with their tutor. “Creativity” and “Collaboration”, two qualities that students experience during EasyA tutoring sessions, help students delve deep into mathematical concepts, finding their own solution in collaboration with EasyA’s tutors. The way of problem posing that the student learns with the support of their tutor when working towards a solution, enables the student to accept the problem (i.e. learn about the assumptions inherent to mathematical problems) and challenge the assumptions (i.e “what-if-notting”). As a result, the student sees the problem from a fresh perspective that extends their understanding.
4. **Confronting Mathematical Anxiety**: EasyA breaks the “Right Way” syndrome common to many students when problem solving in mathematics, by showing that there is no right question, but instead an infinite number of very valid questions. Further, the dialogical approach that is inherent to EasyA’s Q&A-based tutoring sessions, helps the student identify “instrumental questions”. These are the types of questions that pursue a preconceived agenda, usually imposed by tutors themselves rather than the curiosity of the students. Tutors who do not use the dialogical approach often force students, either consciously or subconsciously, to follow their own solution (as a path to finding the answer), i.e. the aforementioned “preconceived agenda” of the tutor. This is one of the reasons learning mathematics may not be an enjoyable task for students; tutors or teachers don’t give students the freedom to find their own solution. Giving students the freedom

to ask questions and find their own solution is difficult, because teachers need to A) accept the limitations of their own knowledge, and B) allow the student to engage in the learning process through questioning, rather than simply lecturing. EasyA's dialogical space provides the student with an encouraging environment to learn to confront their feeling of mathematical anxiety that is grounded in the "Right Way" syndrome and instrumental questioning. Further, EasyA allows the student to ask questions anonymously, so that they can learn without fear of judgment from their classmates or a tutor or teacher who they might meet face-to-face. Thus, the student has the flexibility to reach the solution to a problem using their own method and is never afraid to ask "silly" questions along the way.

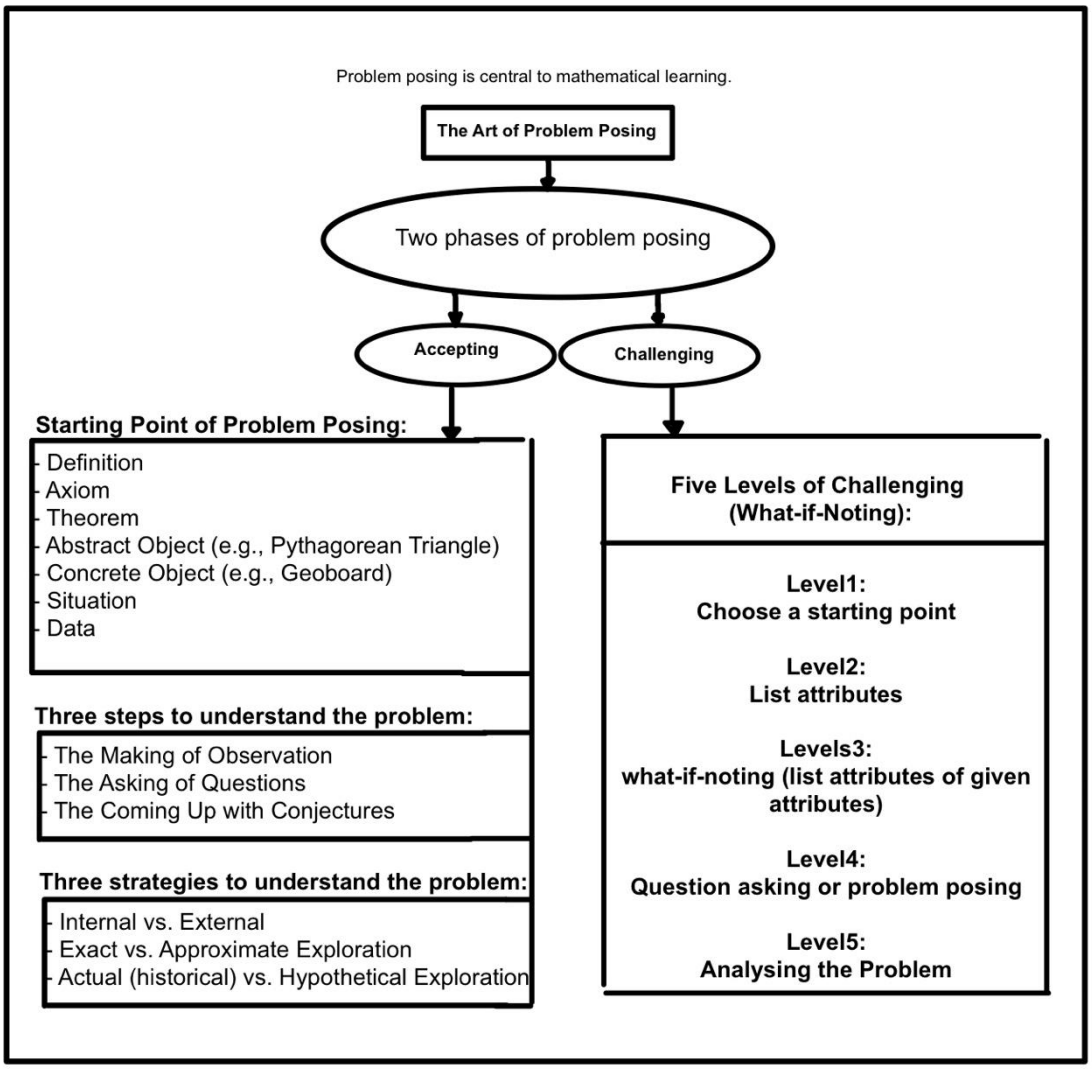
Problem Posing, the Structure of Dialogue in EasyA

Problem posing is central to the mathematical learning process that underpins the way EasyA fosters dialogue between students and tutors in order to help the student reach a solution to their problem. According to Brown and Walter (2005), “Accepting” and “Challenging” are two phases of problem posing: “Accepting” is the degree to which the student accepts the assumptions and “Challenging” is the extent to which the student challenges these assumptions. The following section shows how these two phases are intertwined in the dialogical approach that is embedded in EasyA.

How Students Learn the “Art of Problem Posing” in EasyA

Figure 4 shows how the two phases of problem posing (i.e. “Accepting” and “Challenging”) are embedded into EasyA, as the way in which tutors are trained to help their students realize the “given” and challenge the “given” through the “what-if-not” approach. This figure shows that problem posing begins with the “Accepting” phase. In this phase, EasyA tutors help the student find out what their attitude is towards the assumptions in the problem, by encouraging them to observe, question and make conjectures from the assumptions that are inherent to the problem. An assumption in the mathematical problem could be a definition, axiom, theorem, abstract and/or concrete object, situation and data. To explore these assumptions in the problem, EasyA tutors help the student analyze whether these assumptions are internal, external, exact, approximate, actual or hypothetical. When the student has conducted a thorough examination of their attitude towards the assumptions of the problem, the tutor leads the student towards the “Challenging” phase by asking them to list out the attributes of the problem. Further, the “Challenging” phase continues by asking the students to ask “what-if-not” this attribute. Here, the student poses questions based on those attributes and analyzes any problems.

Figure 4: Problem posing structure in EasyA.



Note: The two phases of problem posing in EasyA are developed based on "The Art of Problem Posing" (Brown and Walter, 2005).

Two Learning Success Factors in EasyA: Creativity and Collaboration

Note that depending on the direction that the student chooses at the beginning of each EasyA tutoring session, the outcome of the problem posing process is linked differently to problem solving (i.e. the solution). EasyA rates the success of each online session in terms of the learning outcome for the student according to two factors of "creativity" (i.e. when the student finds their own solution to the final answer) and "collaboration" (i.e. when the student

enters into dialogue with their tutor that extends their understanding rather than blindly follows the tutor's way of thinking).

Factor 1: Be "Creative" When Finding "A" Solution

The "Creative" factor measures the learning success of sessions that follow the "Problem Solving First, Problem Posing Second" direction. If the student chooses this direction, they start with the solution to the problem. The problem posing process begins with the solution in order to help the student understand how one might arrive at this solution. EasyA tutors support the student in this discovery journey rather than guiding the student blindly. Hence, it is entirely possible that the student finds a different way of reaching the final answer (i.e. the solution) that differs from the path that the tutor has taken. EasyA reviews each session and if the student follows their own individual path to the solution with the support of their tutor, the session is flagged as "Creative", and rated as successful in terms of learning outcome for the student. Both student and tutor are able to rate how "Creative" they felt the dialogue was at the end of the tutoring session. This reflects the extent to which the student could find their own, independent path to the solution.

Factor 2: Be "Collaborative" When Finding "A" Solution

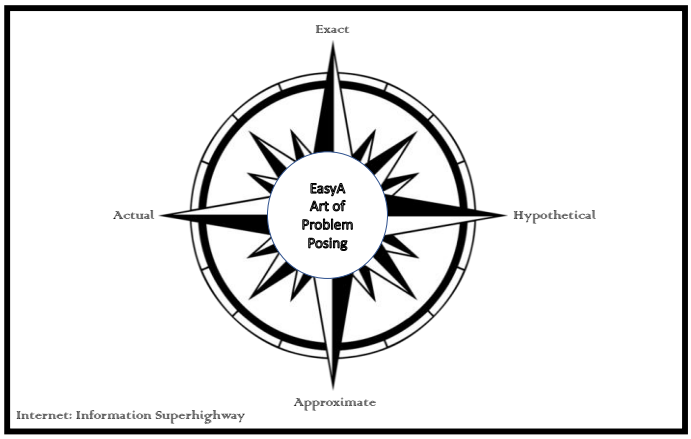
The "Collaborative" factor measures the learning success of the sessions that follow the "Problem Posing First, Problem Solving Second" direction. If the student chooses "Problem Posing First, Problem Solving Second", they do not receive the final answer at the beginning of the session, but start by posing questions to find a solution with the help of their tutor. EasyA rates these sessions as successful if the student arrives at their own solution in collaboration with their tutor, rather than a solution being imposed on them by their tutor. Hence, in this direction, the most successful sessions are flagged as "Collaborative". Both

student and tutor are able to rate how “Collaborative” they felt the dialogue was at the end of the tutoring session.

EasyA "Art of Problem Posing" as a Compass to Protect Children on the Internet

Ensuring child safety on the internet is one of EasyA's top priorities, and our teaching methodology and technology have all been designed with this in mind. EasyA has a rigorous Safeguarding Policy to protect students' safety online. In addition to these practical safeguarding steps, EasyA's dialogical space empowers children to question the unlimited sources of information that are accessible on the internet, as termed the "Information Superhighway" by Bakken and Aloia (1998). An inherent challenge for children in this superhighway is that it provides unlimited and uncensored access to information. The "Art of Problem Posing" that students learn using EasyA helps them to evaluate this information. As a result of this autonomous approach to learning, the student learns how to question information and discovers what to trust when faced with an abundance of such information. This process acts like a compass for students and is a significant learning outcome for students and their families. The sense of autonomy that the student experiences during EasyA tutoring sessions empowers them to learn how to trust their own judgement when they encounter an unknown phenomenon, rather than merely relying on external sources of evaluation. Figure 5 shows that the "Art of Problem Posing", which the student learns by using EasyA, equips them with the four criteria of exact versus approximate and actual versus hypothetical to evaluate information on the internet. The exact versus approximate dimension is the strategy that EasyA tutors use to help their students engage in exploration and not be afraid of not finding an exact answer. It is very important for all students engaged in mathematical learning to explore problems without the fear of not finding the exact answer, as for some problems there may exist no exact answer. The actual versus hypothetical dimension refers to historical exploration that EasyA tutors use to help their students learn about the significance of the problems they are exploring during their sessions. For example, relating the problem in question to broader mathematical theories or concepts.

Figure 5: EasyA Problem Posing becomes the student's compass on the internet.



EasyA Parental Support Program

A key challenge faced by parents in the post-internet era is how to improve their child's learning in the digital space. In recent years, parents have had a growing interest in the best ways surrounding how to mediate their child's digital activities to improve their learning outcomes (Jun, Han, Kim, and Lee, 2014; OECD, 2017). Effective parental involvement in the digital space could improve a child's achievements (Takashiro, 2017) by extending their learning time from taking place not only in school but also at home (Chen, Tseng, and Hsiao, 2018). Built with this in mind, EasyA has a parental support program that includes three main strategies:

1. **Customised Feedback Process**: Through the EasyA parent portal, all parents can see the precise feedback their child's tutors provide, allowing them to see exactly in which topic areas their child is excelling or struggling. Based on the lessons learnt from the Program for International Student Assessment (PISA), which compares student ability in maths and science in OECD countries, this sort of direct feedback mechanism is the most effective tool for parents to track their child's learning in a digital context (Hopfenbeck, Lenkeit, El Masri, Cantrell, Ryan and Baird, 2018).
2. **Parental Sharing Experience Forum**: EasyA also provides parents with a forum where they can share their concerns about the learning process of their child. Recent studies (Majnemer, A., O'Donnell, Ogourtsova, Kasaai, Ballantyne, Cohen, Collet, Dewan, Elsabbagh, Hanlon-Dearman and Filliter, 2019) show that allowing parents to share their experiences with each other is one of the most effective strategies for parents themselves to learn online.
3. **Dedicated Parent Portal**: The EasyA parent portal provides parents with a direct view into the learning trajectory of their child. Parents can view all interactions their child has had with EasyA's tutors in detail, including the exact messages that have been sent by

both student and tutor, allowing parents to witness the precise learning process for themselves. The parent portal allows parents to see exactly in which topic areas their child might be excelling or struggling with in real time, without having to wait for end of term reports to find out.

References

Bakhtin, M.M., 2010. *The dialogic imagination: Four essays* (Vol. 1). University of Texas Press.

Bakken, J.P. and Aloia, G.F., 1998. Evaluating the World Wide Web. *Teaching Exceptional Children*, *30*(5), pp.48-52.

Brown, S.I. and Walter, M.I., 2005. *The art of problem posing*. Psychology Press.

Chen, M.-H., Tseng, W.-T., & Hsiao, T.-Y. (2018). The effectiveness of digital game-based vocabulary learning: A framework-based view of meta-analysis. *British Journal of Educational Technology*, *49*(1), 69–77.

Dewey, J., 1986, September. Experience and education. In *The Educational Forum* (Vol. 50, No. 3, pp. 241-252). Taylor & Francis Group.

Dewey, J. & Bentley, A. (1991/1949). Knowing and the known. In J. A. Boydston (Ed.), John Dewey: The later works, 1949-1952, Vol. 16. Carbondale, IL: SIU Press. [Originally published as Dewey, J. & Bentley, A. (1949). Knowing and the known. Beacon Press.]

Freudenthal, J. and Greve, P.A., 1973. Polychlorinated terphenyls in the environment. *Bulletin of environmental contamination and toxicology*, *10*(2), pp.108-111.

Hopfenbeck, T.N., Lenkeit, J., El Masri, Y., Cantrell, K., Ryan, J. and Baird, J.A., 2018. Lessons learned from PISA: A systematic review of peer-reviewed articles on the programme for international student assessment. *Scandinavian Journal of Educational Research*, *62*(3), pp.333-353.

Jun, S., Han, S., Kim, H., & Lee, W. (2014). Assessing the computational literacy of elementary students on a national level in Korea. *Educational Assessment, Evaluation and Accountability*, *26*(4), 319–332. https://doi.org/10.1007/s11092-013-9185-7

Koschmann, T., 1999, December. Toward a dialogic theory of learning: Bakhtin's contribution to understanding learning in settings of collaboration. In *CSCL* (Vol. 99, pp. 308-314).

Majnemer, A., O'Donnell, M., Ogourtsova, T., Kasaai, B., Ballantyne, M., Cohen, E., Collet, J.P., Dewan, T., Elsabbagh, M., Hanlon-Dearman, A. and Filliter, H.J., 2019. The Parent-Panel (2019) BRIGHT Coaching: A Randomized Controlled Trial on the Effectiveness of a Developmental Coach System to Empower Families of Children With Emerging Developmental Delay. *Front. Pediatr. 7: 332.*

Takashiro, N. (2017). A multilevel analysis of Japanese middle school student and school socioeconomic status influence on mathematics achievement. *Educational Assessment, Evaluation and Accountability*, *29*(3), 247–267.

UK Council for Internet Safety, 2020. GOV.UK, viewed 1 April 2020, https://www.gov.uk/government/publications/child-safety-online-a-practical-guide-for-parents-and-carers/child-safety-online-a-practical-guide-for-parents-and-carers-whose-children-are-using-social-media