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Improving a Multimodal Based Teacher Training Program for Teachers of Gifted: An Educational Design Research

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Abstract

This study is an educational design research on the design, implementation, and evaluation of a Multimodal Based Teacher Training Program (MB-TTP) that aims to improve the representational competence skills of teachers of gifted (ToG). The aim was to describe the design process of the model and the development process of ToG during and after the intervention. Participants were chosen by convenience sampling. The data were collected through the multimodal representations designed by the teachers, their comments on these representations, discussions on the designs and models in the classrooms, and interviews with participants and experts. The data obtained from the artifacts were analyzed according to the analytical framework developed by the researcher. Interviews and discussions were analyzed through content analysis. At the end of micro cycle 1 and 2, the findings showed that teachers gained abilities of identifying, but they were not qualified at selecting/designing and evaluating. At the end of micro cycle 3 and 4, the findings revealed that teachers were able to identify different types of intermodal mechanisms, and their design purposes. At the end of micro cycle 5, the results showed that teachers were able to identify and analyze the adequacy of multimodal representations, as well as to critique the extent to which the representation reflected the relationships between the modes indicated. Finally, the MB-TTP and its design principles were revealed as the result of all these iterations. The findings showed that applying the MB-TTP and its principles improve representational competence skills of ToG.

Key words*: educational design research, gifted education, multimodality, teacher training, representational competence*

Introduction

Gifted individuals differ from peers in their high-level cognitive improvement (Renzulli, 1978). They have abilities of encoding complex information fast in the comprehension process (Clark, 2008), recognizing and constructing causal and correlational relationships between concepts (Sayı & Demir, 2016), experiencing deep learning, self-motivated to learn and acting independently (Sayı & Yurtseven, 2021). They are highly motivated and committed to a task by maintaining attention and internal control (Renzulli, 2003). They have exceptional memory, a rich and extraordinary imagination, and extensive vocabulary (Miedijensky, 2018). Gifted students have a high level of curiosity and enjoy a high level and challenging learning process (Syafril et al., 2020). They are active and creative in problem solving and able to transfer their learning into new situations (Altintas & Ozdemir, 2012; Betts & Neihart, 2010; Vogelaar & Resing, 2018).

Gifted students enjoy and seek challenging teaching materials and processes, and problem solving in the teaching process (Phillips & Lindsay 2006; Sayi & Yurtseven, 2021; Subotnik et al., 2011; Taber, 2007). Over repetition of basic ideas, overgeneralized explanations, inadequate details, and lack of challenges lead to boredom and demotivation (Taber, 2016). Gagne (2010) also indicates that a learning environment which lacks proper challenging activities and content bring about ennui in gifted students. Another problem that gifted students face at school is the inability of teachers to meet the instructional needs of these students (Mammodow, 2019). Students' views in his study indicated that their teachers lacked pedagogical knowledge about appropriate instructional arrangements that offer sufficient challenge to a student.

In brief, the problems encountered by students can be classified into three categories: boredom, lack of challenge, and teacher ineffectiveness. The last one brings about ill designed learning activities, which then lead to boredom, disengagement, and demotivation because they do not provide enough challenge. All problems are mutually reinforcing. Therefore, many scholars agree that there is a strong need for differentiated pedagogy, differentiated teaching and learning activities, advanced activities, and material design that offers challenges and engages students' attention, curiosity, and creativity (Hobden et al., 2012; Housond, 2016; Stott & Hobden, 2016; Ulger & Irving, 2019; VanTassel-Baska & Wood, 2010).

Researchers have introduced various curriculum models for gifted education, including the Schoolwide Enrichment Model (Reis & Renzulli, 2003), the Autonomous Learner Model (Betts & Kercher, 2009), the Purdue Three Tier Enrichment Model (Moon et al., 2009), and the Integrated Curriculum Model (VanTassel-Baska & Wood, 2010). These models highlight two key elements for addressing the needs of gifted students: differentiation through acceleration and enrichment. Acceleration compresses the curriculum for faster academic progression, while enrichment provides greater depth and variety in learning experiences (Davis et al., 2014). Enrichment adapts content, processes, and environments to align with students' readiness, interests, and learning

profiles (Tomlinson, 2005). VanTassel-Baska and Hubbard (2016) emphasize the need for teacher training in these differentiation strategies.

Research indicates that while teachers recognize the need to promote higher-order cognitive skills such as analysis, synthesis, and evaluation (Taber, 2007, 2014), many lack the competence to implement these effectively (Reis & Renzulli, 2003), and few have advanced certification in gifted education (Chan, 2011). Reliance on teacher-centered, textbook-based, and test-oriented methods limits the challenge for gifted students (Yuen, 2004). Scholars advocate for learning environments that emphasize enrichment and differentiation (Coleman, 2014; Dilekli, 2017; Hong et al., 2011). Therefore, teachers of gifted students (ToG) need training in differentiated pedagogy to enhance their effectiveness and address issues of boredom and lack of challenge. Teacher education programs should incorporate diverse teaching approaches to develop these skills.

In this context, the researcher aims to design a pedagogical model for ToG. Before designing the model, a needs analysis was conducted through literature reviews, interviews and analysis of the participants' teaching materials. Once the problems and needs were identified, the researcher looked for possible solutions and then identified the theoretical and practical principles of the model, the learning and teaching process and the types of activities. Research has shown that multimodality and multimodal approach to teaching and learning offer many opportunities to provide a differentiated pedagogy in gifted education. These are described in the following paragraphs.

Multimodality

Multimodality, a term used in social semiotics, has evolved in response to paradigmatic shifts in the social and semiotic landscapes over the last few decades (Jewitt, 2008a, b; Kress, 2009; Shannon, 2014). These changes include two main dimensions: on the one hand, the image is replacing the long-standing dominance of the written word, and on the other, the screen medium is taking over the role of the book (Selander, 2008). The image and the screen medium have become central sources of communication (Bezemer & Kress, 2010).

Studies on multimodality reveal several benefits: it improves student engagement with materials and concepts (Fernandez-Fontecha et al., 2019), enhances meta-reflection on representations (Andersen & Munksby, 2018), increases interest and attention (Keleş, 2016), and fosters active engagement and problem-solving (Cromley et al., 2010; Kim, 2017). Multimodality encourages creativity in developing scientific ideas (McDermott & Hand, 2013), supports knowledge synthesis through analysis of various sources (Wilson & Bradbury, 2016), and enables students to represent concepts in diverse forms, simplifying complex discourse (Taber & Akpan, 2016; Öz & Memiş, 2018). Fontecha et al. (2019) stated that through multimodal representations such as sketch notes, abstract meanings in scientific articles are transformed into concrete forms and condensed ones are unpacked. In this way, the complex form of specialized discourse can be simplified and complicated.

Considering all these, this study aims to develop a model of teaching and learning activity sequence (pedagogy) for Intellectual Disabilities. Therefore, first, a Multimodal Based Teacher Training Program (MB-TTP) with theoretical and practical design principles for gifted education was created through educational design research. The model aims to provide gifted teachers with differentiated teaching methodology, content, activities and materials as their students demand challenging tasks that capture their attention and curiosity, trigger higher-order thinking skills and provide independence in learning. Ultimately, teachers will be competent in designing multimodal texts. With these concerns, the study seeks to answer the following questions:

How was the MB-TTP improved?

2. What are the prior and post levels of teachers' multimodal text design competency?

Methodology

Research design

Educational design research (EDR) is the methodological framework of this study. EDR aims to examine possible solutions to complex educational problems encountered in a real context through a systematic analysis of the design and development of an intervention. It contributes not only to our knowledge of theory, but also to our knowledge of practice and the characteristics of the intervention and the processes of designing and developing it (Plomp, 2013). EDR mainly focuses on how education can be, or even how it should be (Bakker, 2018). This means that educational researchers often have a desire to solve a problem they have encountered. In EDR, research and design are intertwined and interdependent. Designing teaching materials or a professional development program is intertwined with the iterative cycles of testing and improving of theory, or vice versa (Bakker, 2018). That is, design tests develops theory in different contexts, and developed theory leads to the creation of new designs. In general, EDR commonly has three research phases: (1) preliminary research phase, (2) prototyping or development phase, and (3) evaluation phase (Nieveen & Folmer, 2013; Plomp, 2013).

Participants

The participants were chosen from Science and Art Centers (SACs) through convenience sampling. SACs are public pull-out schools which serve gifted students as after-school programs. These schools aim to meet the educational needs of gifted students in primary, middle, and high school through enrichment and grouping (Sak, 2010). There were one or two science teachers in these schools. These teachers were invited to participate in this study with online and face to face meetings. During these meetings, they were informed about the process and aims of the study, the roles and responsibilities of the researcher and the implementers, what was expected of them, and the research timeline. They were also informed about the study goals, the collaborative process between the researchers and practitioners, and the scope, content and products of the research.

The four ToG voluntarily agreed to participate in this research. Two of them were male and two were female. One of them holds a bachelor's degree, two hold master's degrees and one holds a doctorate degree. All of them are experienced in teaching science to gifted students, with an average teaching experience of 7 years. They work in different regions of Turkey.

Data collection and analysis

The present study used qualitative data to investigate improvement of a teacher training program and ToG's developments of representational design skills during and after exposure to the MB-TTP. The semi-structured interviews was carried out with participants and experts on their views and perceptions regarding the model, the teaching and learning processes, and activities. Teachers' representations which were designed in each phase were also collected to track their developments.

Interviews and discussions were qualitatively analyzed through content analysis. Data were coded, categorized and finally themes were identified (Savin-Baden & Major, 2023). The data obtained from the artifacts designed by the participants were analyzed according to the analytical framework developed (Gül & Costu, 2021). The framework is based on the systemic functional multimodal discourse analysis approach. Based on the analytical framework, intermodal relations between image-text are classified into two groups, four levels, and eight categories. Two groups refer to concurrence and complementarity. The former one includes two levels (Level 1 and Level 2) and four categories (decorational, exemplary, representational, and exposition). The latter also consists of two levels (Level 3 and Level 4) and four categories (comparative, organizational, augmentation, and interpretational).

Research procedure

Preliminary phase

In this phase, the researcher firstly aimed to determine problems experienced by ToG in a real educational context regarding the use and design of multimodal representations. To do this, teachers' representations were collected and analyzed on a case-by-case basis to see if they were representationally competent. Then, the researcher conducted a year-long literature review to define the problem, identify possible solutions, create teaching and learning activities, decide on the theoretical and conceptual frameworks of the study, establish the intervention model and principles and analytical frameworks (see Fig. 1). During this year, the researcher also participated in national and international academic meetings related to gifted education. The researcher found that there were no attempts and studies to design a pedagogical model in order to make ToG representationally competent.

At the end of all these processes, the researcher developed the conceptual or theoretical framework of the study, identified the theoretical and practical principles and finally designed a draft model for the intervention (Bakker, 2018; Plomp, 2013). That is, at the end of the preliminary phase, a draft model emerged with a set of draft design principles to solve the problem.

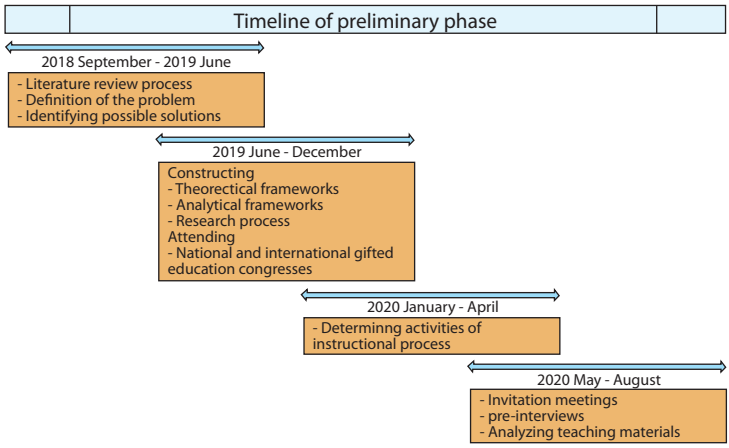


Figure 1. Timeline of the preliminary phase

Prototyping phase

The prototyping phase is the second step of EDR. It involves iterative applications of the draft model, i.e. micro-cycles (See Fig 2.). Each micro cycle underwent a formative evaluation in order to revise and develop the intervention. In the study, five micro cycles were conducted to obtain a robust model that could improve representational competence of ToG in the study. In each micro cycle, ToG used different interactive learning environments (Seesaw, Google Classroom, Thinglink, Piktochart and others). At the end of the fifth microcycle, the researcher concluded that the intervention turned into an effective model for developing ToG's multimodal text design competence.

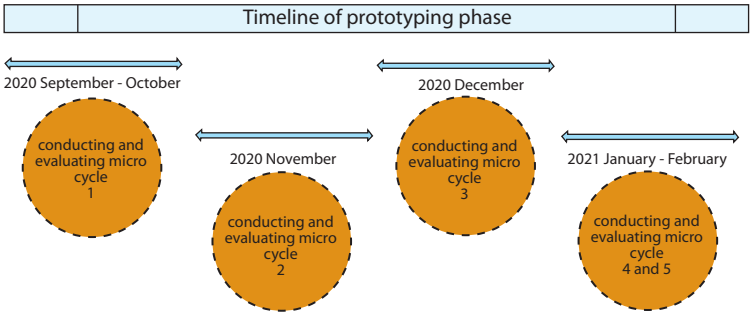


Figure 2. Timeline of the prototyping phase

Evaluation phase

Retrospective analysis was conducted in this phase from the beginning of the preliminary phase to the end of the development phase. The individual processes of the participants and the analysis of the intervention model were evaluated overall from a comprehensive perspective. In this way, the study reported the final version of the intervention model and its further implications.

Results

Preliminary phase

The findings revealed that ToG are not qualified at using, selecting, and designing high levels of multimodal representations (see Fig. 3). These data showed that teachers have limited explicit knowledge about intermodal relations in multimodal representations. The results also indicated that ToG have limited knowledge about how to use different types of representations for several pedagogical purposes in the digital or real classroom environment (see Fig. 3). Some examples of the representations used by teachers before the intervention are presented in Table 1. At the end of the preliminary phase, the researcher also improved draft theoretical and practical principles of the MB-TTP.

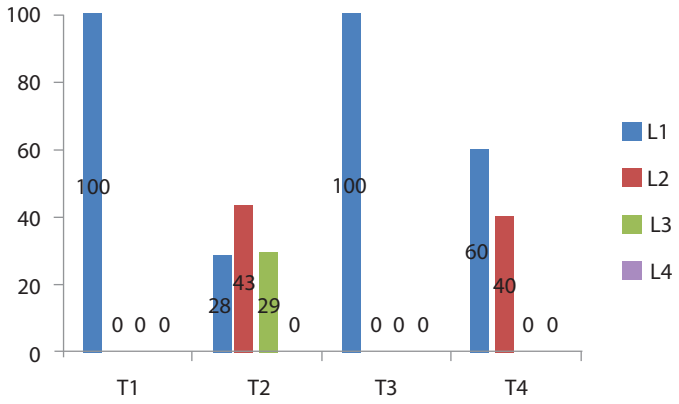


Figure 3. Percentage of intermodal relations in teachers' representations

Table 1

A few examples of multimodal texts before the intervention

Examples of the law of inertia • When we are traveling in a car and the car brakes and we move forward. • Moving backwards when the car starts moving from a standstill. • When we shake our wet hands and water splashes all over the place. • The motion of rocket launched into space	Monomodal The text (examples of law of inertia) only includes writing mode
 Scientific Methods A series of steps used by scientists to solve or answer a problem. Step of scientific metod: - Observation - Hypothesis - Experimental design - Analyzing - Conclusion	Exemplary While the text explains what the scientific method is and what its steps are, the visual only gives a clue about the observation part.

The MB-TTP. The aim of designing such a model is to propose an environmental catalyst for developing a specific ToG competence, called multimodal text design competence. This competence enables them to design challenging teaching and learning materials for gifted students. Therefore, MB-TTP was created considering how the teaching and learning process takes place in a multimodal way. The teaching process of

MB-TTP is explained by considering Peirce's triadic relationship between sign, object, and interpreter, Robert's (1996) trialogue and the parameters of social semiotic theory: semiotic system, text and choice (interest). The study explains these triads based on Waldrip et al.'s (2010) interlocking triad (see Figure 4). This triad is based on Peirce's triangular model of meaning making. According to this framework, the learning process involves the elements of "Teacher Concept (TC)", "Teacher Representation (TL)", "Student Concept (TC)" and "Student Representation (ST)". Each pair forms the Peirce meaning essay with the "Domain (D)", the content to be taught/learned. That is, teaching and learning is a dynamic cyclical process of 'designing' between the domain being taught (D), teacher representations (TR), teacher concepts (TC), student representations (SR) and student concepts (SC) (Waldrip et al., 2010).

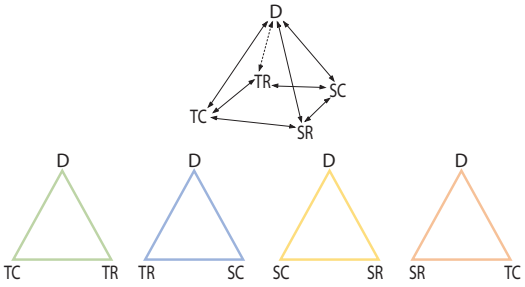


Figure 4. Interlocking triad by Waldrip, Prain, & Carolan (2010)

Since the study claims that learning is a design and explains how to learn with multimodal representations, how the learning processes should be organized as a teaching process was explained by adapting the New London Group (1996), Robert's (1996) trialogue, Designed by Framework (Cope & Kalantzis, 2015), and Design for Learning (Selander & Kress, 2012). In other words, it explains how the teaching process is formed according to learning steps and how learning occurs mentioned before. The study argues for the teaching process within the same scopes of the New London Group, with some adaptations from studies by Cope and Kalantzis (2015), Selander and Kress (2012), and Lim (2018). All of the four stages of the model mentioned below are operationalized around these studies.

Designing pedagogical environment (DPE). In this phase, the teacher immerses learners in a semiotically rich environment with meaningful practices, offering a variety of designs that reflect both familiar and new experiences (Jewitt, 2008; Lim, 2018). These available designs, which are scaffolded by the teacher, should balance familiarity and novelty (Cope & Kalantzis, 2015). They may include standard curricula like textbooks and exercise books, as well as more complex materials that suit the students' expertise level (Selander, 2008).

Available designs encompass both defined curricula and additional materials that enrich the learning experience in terms of depth, diversity, and difficulty. These materials could range from textbooks and exercise books to more advanced multimodal

resources like infographics, animations, and videos. The teacher's multimodal text design competence plays a critical role, allowing them to select or design the most appropriate representations for scaffolding students' understanding. This competence involves an awareness of intermodal mechanisms and the ability to design materials that engage learners and support their interpretation. This step serves as the preparation phase of teaching, where the teacher internally (theoretically) and externally (practically) designs the learning environment and processes based on student needs. The teacher determines how knowledge will be formed and transformed, informs students about key concepts, expected outcomes, and evaluation criteria (Selander, 2008).

The process involves three key elements: student representation, interests, and perceptions. Teachers create opportunities for students to generate, refine, and rework their representations, encouraging an active and exploratory learning process. Activities are designed to reflect students' interests and values and must have a strong perceptual context to support meaningful engagement.

Teaching metalanguage (TM). This phase starts with a representational challenge presented by the teacher, the challenge includes a task based onstudents' interests, wherein students are encouraged to accomplish more complex tasks than they can accomplish on their own. Thus, this situation leads to collaboration between teacher and student, and makes both of them active. During the collaboration, students gain conscious awareness about teacher representation and the use of metalanguages which refer to inner and intermodal mechanisms within and between modes (New London Group, 1996). Teachers' coherent multimodal representations motivate and encourage students in accomplishing complicated tasks (Forsling, 2019). TM is a crucial pedagogical strategy in which students are taught and recognizedesign elements, systematic knowledge about analytical vocabulary in meaning making, and how modes are orchestrated in constructing multimodal representations (Cope & Kalantzis, 2015; Jewitt, 2008; Lim, 2018).

In this way, students gain awareness about and recognize affordances and limitations of teacher representation and the use of metalanguages which refer to inner and intermodal mechanisms within and between modes (New London Group, 1996). During the recognition process, a teacher pays attention to give explicit instructions about the following:. (1) The form and function of modes if he starts a novel representation, (2) how the function of mode is realized by its form, (3) how a representation encodes and presents information, (4) how information is distributed among modes which can complement or constrain each other, and (5) introduce different types of intermodal mechanisms (concurrence and complementarity).

In TM, domain (coherent and meaningful multimodal representations) and representational challenge presented by teachers become a set of all new available designs for students (D). Teachers introduce metalanguage/intermodal mechanisms of multimodal representations (TR), and then students construct their own new conceptions/new schema in their mind/internally (SC). In the intersection of overt instruction and critical framing, internal designing continues.

Critical framing (CF). The students create their internal design first by analyzing teacher created representations and then by transforming the known representations to new ones to the current contexts wherein a problem is situated, using metalanguage that they become aware of. Moreover, students reflect on their conceptual understanding, designing, and design (Kress & Selander, 2012). In this step, students integrate new schemas with existing schemas in long term memory by internalizing. That is, critical framing includes two basic steps: *analyzing* and *internalizing by design*.

Analyzing involves making logical connections such as deduction and induction, process of reasoning, and establishing functional relations such as causation. The process is realized functionally through analyzing structure, function, context of knowledge and how knowledge is presented. Learners ask themselves, and interrogate the texts provided by the pedagogical environment according to the following questions: What does it do? How does it do it? What is its structure, function, relations, and context? (Cope & Kalantzis, 2015; Lim, 2018). The internalization process means that the designer creates a final schema in his/her mind by examining and analyzing the multimodal texts curated by the teacher according to his/her own interests and preferences. Critical framing is a basement for transformed practice because this process helps designers frame their growing mastery in designing, analyzing, conscious control, and understanding.

Transformed practice (TP). In this process, students challenge and re-examine what they have already learned. They are presented with a new representational challenge in different contexts. They are asked to recreate and recontextualize meaning across contexts (Jewitt, 2008). In a sense, transformed practice restarts the teaching process and goes back to where we started.

The designer applies what has been learned and adapts experiential, critical, and conceptual knowledge from one context to a different context (Lim, 2018). In short, by leaving the current context, students are introduced to a new task and asked to apply it in a new context to show whether the representation works in new contexts. Thus, the teaching cycle starts again. So, as Kress puts it: "engagement with it in transformative action; which constantly remakes my inner resources; and in that, changes my potential for future action in and on the world." (Kress, 2010, p. 14).

In DPE, the teacher selects the key concepts (domain) to teach, designs internal representations by choosing from all available design options (TC), constructs external representations (TR), analyzes the adequacy and competence of the representations, and then plans how to present them. This is carried out considering two important patterns: (1) decreasing extraneous load and increasing/decreasing intrinsic load according to the level of student expertise, (2) designing a representational challenge process. In TM, domain (coherent and meaningful multimodal representations) and representational challenge presented by teachers become a set of all the new available designs for students (D). Teachers introduce metalanguage/intermodal mechanisms of multimodal representations (TR), and then students construct their own new concepts/new schemas in their mind/internally (SC). At the intersection of TM and CF, internal

designing continues. At the end of CF, students design their external representations by combining existing schemas with new schemas (SR). In transformed practice, students are immersed into a new context (D). According to the needs of the new context, they construct their conceptions (SR).

In short, (1) teachers firstly design multimodal representations internally, then externally (teaching materials), (2) present them to the students, (3) students comprehend these texts, and design what they have learned as a multimodal text in their minds, (4) then they design a learning product multimodally to show what they have learned, (5) finally, teachers assess these products, and give feedback.

Prototyping phase

Micro cycle 1

The findings revealed that all participants gained the ability to select and integrate appropriate images and texts from the available texts provided by the researcher. That is, they were good at finding and selecting appropriate ones from the available ones. It should be noted that the participants designed all types of intermodal relationships, even if the majority of their representations belonged to the primitive level category (Levels 1 and 2) (see Fig. 5 and Table 2). They tended to design high-level multimodal representations (Levels 3 and 4) (rarely augmentation and interpretation).

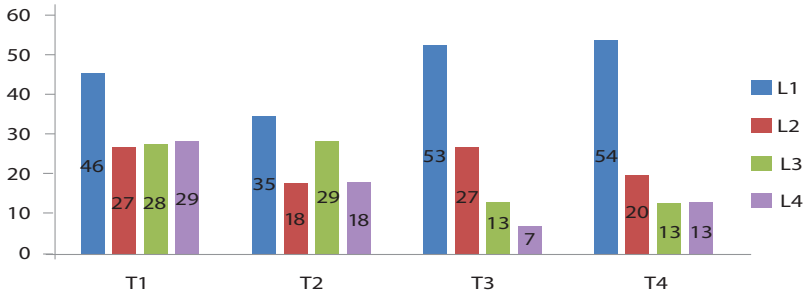
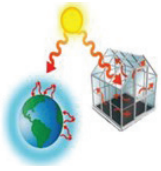


Figure 5. Percentage of intermodal relations in teachers' representations at the end of micro cycle 1

Table 2

A few examples of multimodal texts in micro cycle 1

 Greenhouses Gases and Global Warming The Erth's atmosphere (gas layer) passes the sun's rays and absorbs some of it.	Representational The statement in the text (The Earth's atmosphere (gas layer) passes the sun's rays and absorbs some of it.) is reflected by the image.
and greenhouse gages in the atmosphere:  A greenhouse receives heat from the sun during the day.	Comparative The text and image together provide readers to understand similarities and differences between greenhouse and greenhouse gases in the atmosphere.

Micro cycle 2

In this step, although the researcher gave the participants only half of the available resources (all resources were provided) and, unlike in the previous step, provided questioning-based feedback instead of explanatory feedback, the results showed that their design evolved from Levels 1 and 2 to Levels 3 and 4 (see Fig. 6 and Table 3). However, it is clear that although teachers had many opportunities to design comparative, organizational, augmentation and interpretation relationships to complement the semi-completed infographic, they did not use them. Considering all these findings, it can be concluded that ToG's representational design skills increased slightly throughout the process and compared to the previous design activity.

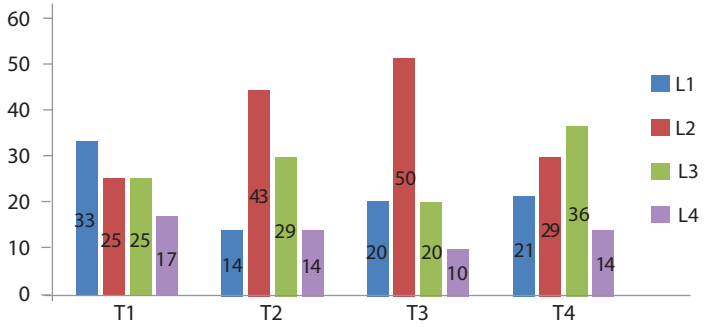
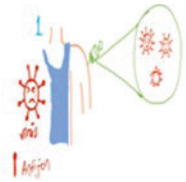
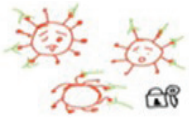


Figure 6. Percentage of intermodal relations in teachers' representations at the end of micro cycle 2

Table 3
A few examples of multimodal texts in micro cycle 2

 The weakend or dead virus is introduced into the body along with some fluids in the vaccine. When germs enter the body, our immune system recognizes them and tries to eliminate them. It does this by detecting antigens	Exposition Weakened viruses are viewed as emojis in the same generality. The image and the text reflects the same meaning, but with different semiotic sources.
 Each antibody recognizes the antigens that sorround the virus and binds tightly to the target antigen.	Augmentation The key-lock symbolizing in the image is stated as a targeted antigen in the text.

Micro cycle 3

At the end of the design activity of micro cycle 3, although the scaffolding level decreased and teachers enabled inquiry-based feedback, the design skills of participants improved as compared to the previous micro cycle. The number and diversity of high level multimodal representations designed increased (see Fig. 7 and Table 4). The findings revealed that teachers developed abilities of selecting and then combining appropriate images and texts by finding on their own from any available resources in

the digital and real learning environment. In brief, it was concluded that the participant teachers improved upper level representational skill of designing in this micro cycle together with the ability of selecting.

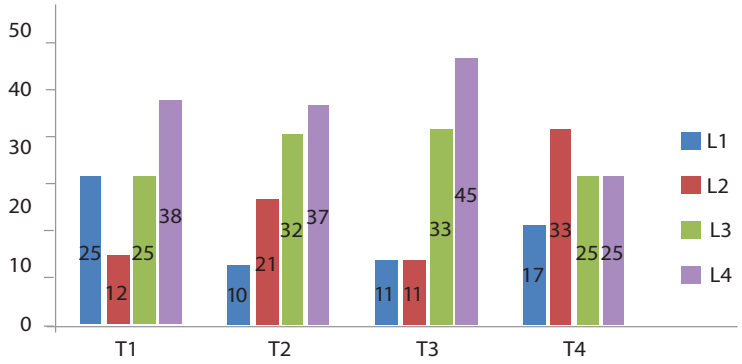
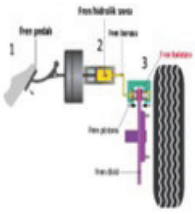
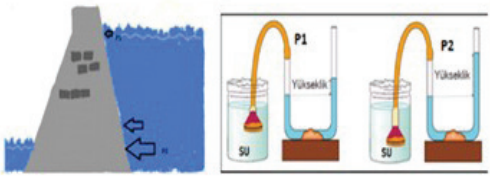


Figure 7. Percentage of intermodal relations in teachers' representations at the end of micro cycle 3

Table 4

A few examples of multimodal texts in micro cycle 3

 Hydraulic brake use hydraulic oil pressure to operate the braking organs of the vehicle. 1. When force is applied from the brake system to the pedal, the piston of the master cylinder builds pressure. 2. This pressure reaches the wheel cylinders through pipes. 3. Braking is provided by opening the pistons of the wheel cylinders The pressure acting on the brake center pump is transferred equally to all the wheel cylinders.	Organizational The image and texts together state how the hydraulic system works by sharing meaning.
Why are the parts of dams built thicker? 	Interpretational The answer to the question of why the lower part of the dam walls are built thicker is asked to solve with another image by making causal relationships.

Micro cycle 4

At the end of design activity of micro cycle 4, design skills of ToG improved as compared to the previous micro cycle. The number and diversity of high level multimodal representations designed have increased. The findings revealed that teachers improved their abilities to select and integrate appropriate images and texts from various resources in the digital and real learning environment (see Fig. 8 and Table 5). Participant teachers designed almost all types of multimodal representations considering the elements of intermodal relations. Hence, they can be called as representationally competent in terms of selecting (identifying) and designing skills.

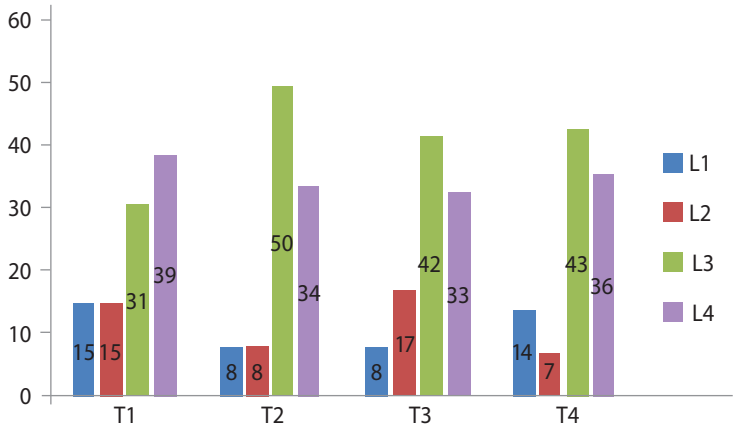


Figure 8. Percentage of intermodal relations in teachers' representations at the end of micro cycle 4

Table 5

A few examples of multimodal texts in micro cycle 4

1. Artificial selection and natural selection 2. Natural selectiona occurs. 3. The best traits are selected by people for the next generation. 4. This process is repeated many times. 5. Over time, product quality improves. 6. In artificial selection, non-resistant organisms disappear after a while.	Comparative The images and the text ask readers to compare and understand differences between natural selection and artificial selection.
How can we use artificial selection? How to obtain crops with new traits based on behavioral genetics. You can think in terms of Mandelian crosses.	Interpretational The image and the text ask reader to make causal relationship between mendel cross and artificial selection

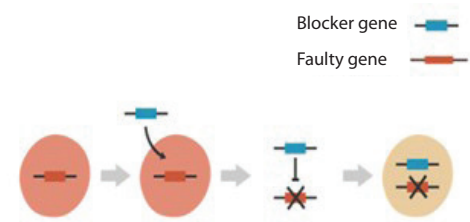
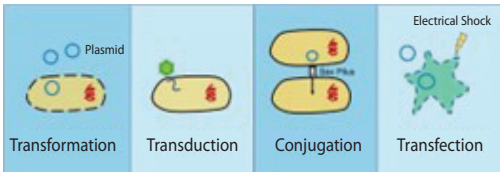
Micro cycle 5

At the end of the design activity in micro cycle 4, the design skills of ToG have improved compared to the previous micro cycle. The number and diversity of designed high-level multimodal representations increased. The findings revealed that teachers improved

abilities to select and integrate appropriate images and texts from various resources in the digital and real learning environment of (see Table 6). The participating teachers designed almost all types of multimodal representations considering the elements of intermodal relations. Hence, they can be called as representationally competent in terms of selecting (identifying) and designing skills.

Table 6

A few examples of multimodal texts in micro cycle 5

 Gene reduction therapy: When a blocker gene is inserted into a cell containing a defective gene, the cell functions normally.	Augmentation has been used as an intermodal relation. Gene reduction therapy is modeled with new icons. It also includes exposition. It is poor/fair/good in meeting the intermodal relations I mentioned above.
 How do bacteria become more resistant?	Interpretational has been used as an intermodal relation. It also consists of comparatives. It is poor/fair/good in meeting the intermodal relations I mentioned above

Micro cycle 5 was conducted as an exercise to verify whether the participating teachers were representationally competent in terms of their evaluation skills, since so far, they had only evaluated their own multimodal representations. Therefore, the researcher presented the teachers with an evaluation matrix and asked them to evaluate any of their peers' multimodal artifacts. The data show that ToG have the ability to identify intermodal relationships and the extent to which they exist. Moreover, they made suggestions to their peers about what kind of relations and textual qualities they should use.

Evaluation phase

In a design-based research, the evaluation process is conducted through the research. The evaluation of micro cycles is carried out in order to follow the development of the participants' skills and refine the model as a result of the intervention implemented during and after the process. As a result of the data obtained from these evaluations, conclusions are drawn about the design principles of the intervention model and the model itself.

Findings on evaluation of micro cycles 1 and 2

As indicated in the findings section, when all the cases were analyzed individually and all the designed representations were considered as a whole (see Fig. 9), it was observed that the teachers' tendency to use different types of intermodal relationships increased. The data also showed that the number of high-level intermodal relations used by the participants increased. However, it is too early to say that they are representationally competent as they created low levels of intermodal mechanisms in activities 3 and 4, even though all available text and visuals were provided by the researchers.

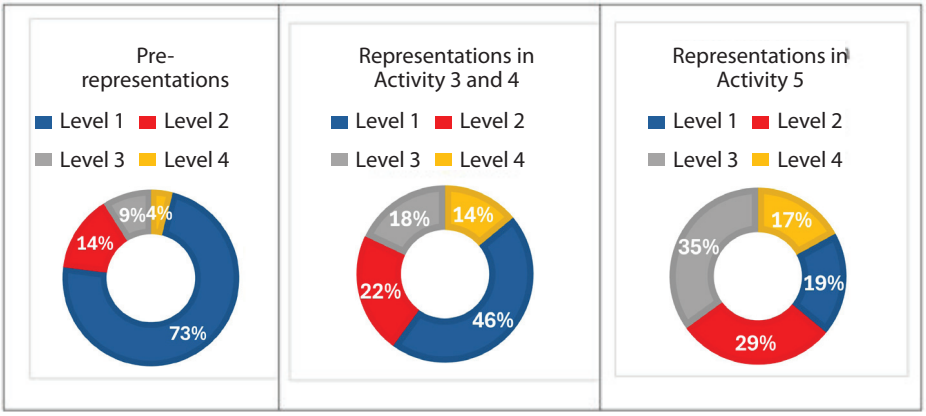


Figure 9. Total change in intermodal relations used by all teachers during the process

Other reasons why they are not accepted as representationally competent can be indicated as follows. The former, teachers experienced difficulties in designing comparative, organizational, augmentation, and interpretational relations. That is, they were not capable of using high levels of intermodal relations effectively. The latter is that they did not take advantage of using appropriate intermodal relations although having this opportunity provided by topic.

To summarize, teachers are able to identify these intermodal relations through discussions and sometimes it was seen that they still could not apply these intermodal relations because they did not recognize them at all. Nevertheless, in light of all these data, it can be argued that the participants became more skilled in establishing higher level intermodal relations. This shows that the MB-TTP can be effective in making participants to be representationally competent. However, some refinements and improvements are also needed. Therefore, the researcher decided to make some improvements on the model through discussions with experts and participant teachers. The discussions with the experts and participating teachers revealed that four main improvements needed to be made about the model and the implementation process. The suggested refinements and additions are related to representational challenges with scaffolding level, self-assessment, medium of application, and overt instruction.

Findings on evaluation of micro cycles 3 and 4

When investigating all cases individually as stated in the findings part, and examining all designed representations in total (see Fig. 10), the tendency of teachers to use different types of intermodal relations was improved. Data also showed that the number of high levels of intermodal relations used by participants have increased. However, it is still too early to indicate that they are representationally competent since they constructed low levels of intermodal mechanisms in activity 3 and 4 despite the text and images being provided by researchers.

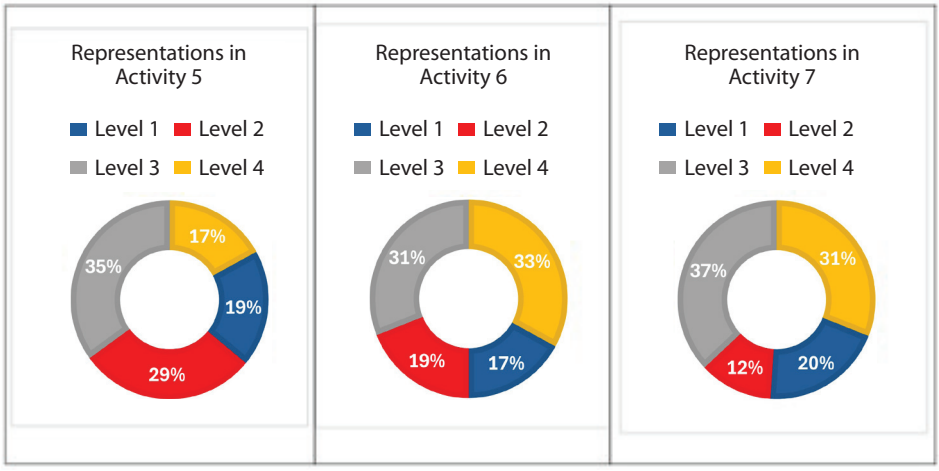


Figure 10. Total change in intermodal relations used by all teachers after micro cycles 3 and 4

As seen in Figure 10, making refinements and applying them to the model impacted the use of high level and low level intermodal relations. Although representations of case five highly affect the rates, the rate and number of high level ones increased (52%-66%-68%; 27-33-40), the rate and number of low level ones decreased (48%-36%-32%; 25-19-19).

Discussions made with experts and participant teachers showed that two important points should also be emphasized in order to make the model more comprehensive. The former, interaction between participants should be considered. In this way, the pedagogical environment can be enriched and overt instruction can be strengthened because participants have the opportunity to view new types of multimodal representations as available designs. For instance, T2 stated that:

"For example, I was curious about what other friends have done, I would like to see their representations, as there are a few more resources, you learn more from friends, or a resource in that sense."

T3 also pointed out that:

"I wonder what others have done too, seeing their representations can help me learn, and I would have seen more resources about these relationships."

The latter point indicated by the experts is that it was not sufficient for the participants to evaluate their own representations. Hence, they need to assess peer's representation in different contexts. In this way, it can be precisely determined whether they are representationally competent . This also strengthens the critical framing part.

For example, Expert 3 stated:

"In the previous process they only analyzed their own representation, this is an important point to see if they made a conscious choice. Another point is that the participants did not design some intermodal relationships, you cannot identify whether they are identifying these intermodal relations or not. Therefore, analyzing other people's representations will give us complete information. Peer evaluation can be added."

Based on micro-assessment 2, the researcher improved the model again by adding a presentation section where the participants presented their designs to their peers. In this way, the researchers aim to improve the interaction between the participants. Furthermore, peer review was added to enrich the transformed practice and critical framing sections.

Findings on evaluation of micro cycle 5

The analysis of participants about intermodal relations and their statements about representations revealed that they were capable of identifying intermodal relations. The findings indicated that they not only analyzed, but also critiqued the extent to which the representation correspondence to the intermodal relations referred to. Moreover, they gave suggestions to their colleagues on which types of relationships to use.Their answers to the questions in the interview were also in line with the representations they designed and their analyses. These parameters show that they also gained analytical skills and critical perspectives on what kind of intermodal mechanisms are designed in a representation. These are clear signs of representational competence skills. Therefore, all these data show that there is no need for a new revision.

Revisions of design principles at the end of micro cycles 1 and 2

Based on the evaluation, some additions and refinements were made to the design principles. Three of them were revised and one design principle was added based on the data obtained in micro cycles 1 and 2, and the suggestions from experts and participating teachers. A self-assessment point was added to improve teachers' representational competence skills of evaluation. Moreover, the researcher decided to gradually increase the level of representational challenge, decrease the scaffolding level, and enrich the available resources in each activity in order to improve teachers' skills in selecting and designing representations. These are shown in Table 7 with the rationale).

Table 7
First revised and added design principles and its rationales

Initial DP	Revised DP	Rationale
At the end, designers' learning products (multimodal representations) should be assessed by the teacher who is an epistemic authority according to multimodal assessment rubrics.	External representations of students should first be evaluated themselves considering intermodal relations, and then evaluated by the teacher according to the criteria of multimodal analysis.	Making self-assessment may be a crucial factor for the process of critical framing in which teachers can reflect on their designing. Teachers should support explicit discussion about multimodal representations and help students to evaluate the usefulness of particular representational forms.
Designers require to encounter represent ational challenges, to develop causal explanations of phenomena.	Designers need to face increasingly difficult representational challenges, the level of scaffolding provided by teachers needs to decrease in parallel with increasing difficulty.	Representational challenge with decreased scaffolding can be effective in improving teachers' representational competence since data provided by researcher give some clues about this inclination.
Teachers should present designed multimodal texts by harmonizing and organizing available designs.	Teachers should present designed multimodal texts in different mediums, such as video and handbook in order to enrich pedagogic environment.	Overt instruction in model should be enriched apart from the videos and feedbacks given by the teacher since it is too hard to comprehend high level of intermodal relations.
	Added DP	
	Designers should be free to choose the applications in which they design multimodal representations.	Since each participant has different qualifications on using different digital problems while designing their representations, most of them suggested that leaving the participants flexible in selecting the medium may be beneficial in terms of constructing.

Revisions of design principles at the end of micro cycles 3 and 4

Based on the findings regarding evaluation of micro cycles 3 and 4, one design principle was revised and a new one was added. The issue of peer assesment was added in order to improve participants' representational competence skill of evaluation. Interaction between teachers was provided in order to improve teachers' representational competence skill of selecting and designing. These refinements are shown in Table 8 accompanied by the rationale.

Table 8
Second revised and added design principles

Revised DP	Final DP	Rationale
External representations of students should first be evaluated themselves considering intermodal relations, and then evaluated by the teacher according to the criteria of multimodal analysis.	Evaluation of external representations should be realized in three following steps: self-assessment, peer assessment, and assessment by epistemic authority.	Making self-assessment and peer assessment is a crucial factor for the process of critical framing and to understand whether participants are representationally competent or not.
	Added DP	
	Multimodal learning environment should provide some opportunities for interactions of designers.	In this way, learners could help each other in order to overcome problems in such interactions.

Discussion

In this section, the findings of the study are discussed and conclusions are given. The discussion was conducted under two main but intertwined headings. In the first one, since the study is an educational design research conducted *through intervention* (McKenney & Reeves, 2014), the findings obtained for the development of the MB-TTP are discussed. In the second title, the impact of the model on ToG's multimodal text design competence is discussed. The second section discusses the impact of the model on ToG's competence in designing multimodal texts.

The MB-TTP

At the end of micro cycles 1 and 2, the results indicated that teachers adopted a slight tendency towards selecting high level multimodal representations among the available ones and to orchestrate different modes considering the relevance of the topic and their aims in the teaching process. Although teachers' views of their external representations showed that they were aware of inter-modal relations and intended to design them, they maintained their habit of designing low-level inter-modal relations. In short, the findings in the first micro cycles showed that teachers were good at

identifying and then selecting high-level multimodal representations, but struggled to design them on their own.

At the end of micro cycles 1 and 3, the findings revealed that while teachers improved in identifying, describing, and recognizing intermodal relationships, they struggled with design. This is similar to Tolpanen et al. (2016), who found that lessons on multimodal writing increased students‘ use of multimodal representations but did not fully teach them how to integrate modes. Based on interviews and collected data, revisions were made to the model‘s design principles, emphasizing the need to present challenges step by step, which can enhance representational competence (Hubber & Tytler, 2017; Tytler et al., 2013). Hubber and Tytler (2017) designed an Astronomy lesson for eighth graders based on a series of representational challenges, and the results showed that students started to design more detailed and topic-oriented multimodal representations. As a result, the previous design principle was revised as follows:

"Designers need to face increasingly difficult representational challenges, the level of scaffolding provided by teachers needs to decrease in parallel with increasing difficulty."

The second point is the emphasis that self-assessment will contribute to the development of representational competence. In the first iteration, since the teacher was the epistemic authority, it was thought that their assessment would be useful and sufficient. However, participants and experts thought that self-assessment could be effective. The literature review also showed that this point can be important (Andersen & Munksby, 2018; Kohl & Finkelstein, 2005; Tippett, 2016). In line with the views of participants and experts, Kohl and Finkelstein (2005) found that students' self-evaluation of the representations they designed while solving physics problems improved students' representational competence. Therefore, the previous design principle was revised as follows:

"*Students should make self-assessment of their multimodal representations with respect to the criteria of intermodal relations and text coherence, and then the teacher should assess and give progressive feedback to students' representations*"

Another point emphasized in the findings is the issue of flexibility in the use of digital applications that enable students to design representations. Although the application tools were introduced to the participants, such guidance did not enable them to use them effectively, so teachers should be flexible in using digital tools. The teachers stated that this flexibility would facilitate designing better representations. For example, T1 stated the following:

"*I'm dealing with photoshop a little bit, could we design it with the tool we wanted and send it to you? Maybe we could use slightly different applications, so I think it might be better to be flexible about using apps.*"

Thus, a new design principle was added:

'Designers should be free to choose the applications in which they design multimodal representations.'

The latest change is that a handbook is needed because explicit instruction with multimedia tools such as video and animation creates difficulties in accessing available designs provided by the researcher. For instance, T3 stated that:

"*The videos and animations are prepared very well, thank you, if there is a written document in front of us, we can benefit from it, it is very difficult to find among the videos, so the return could be easier, it would be nice if it was a full text.*"

This situation showed that the learning styles of experienced teachers should be taken into consideration, so DPE should be enriched in terms of available designs. Hence, the previous design principle was revised as below:

"Teachers should present designed multimodal representations in different mediums, such as video, animation, and handbook in order to enrich the pedagogic environment."

At the end of micro cycles 3 and 4, the analysis of teachers' external representations and interviews revealed an increase in high-level multimodal designs and a decrease in lower-level ones. However, this did not fully indicate representational competence. Teachers were able to design and explain the purpose of different intermodal relations, suggesting growing competence. Experts recommended further testing in varied contexts to confirm this finding. Additionally, teachers should guide students to evaluate both their own and peers' multimodal representations to fully develop these competences.

In light of all these views, a new literature review was conducted and it was determined that interaction will increase the number of multimodal representations they are exposed to. In other words, new representations will provide diversity in existing designs, enable them to learn from each other, and improve their representational competencies by increasing dialogue and interaction (Danish & Phelps, 2011; Gebre & Polman, 2016; McDermott & Hand, 2013, 2016; Oz & Memis, 2018). As stated in Danish and Phelps' (2011) study, encouraging students to peer evaluate and give feedback to their peers when designing multimodal representations improved their representational competence skills. As interaction increased, students became more critical of each other's representations, which led to the emergence of better representations. Similarly, Gebre and Polman (2016) reported that students' receiving feedback from their peers while designing infographic-based science news helped them create well-organized multimodal representations. Thus, one principle was revisited and a new design principle was added.

The revised principle is that:

"Evaluation of multimodal representations should be realized in three following steps: self-assessment, peer-assessment, and assessment by teacher."

The added principle is:

"Multimodal learning environment should provide some opportunities for interactions of designers during implementation."

At the end of the micro cycle 5, the analysis of participants about intermodal relations and text coherence, and their statements on peers' text were analyzed. The

results indicated that teachers were not only able to identify and analyze adequacy of multimodal representations, but also able to criticize the extent to which the representation reflects the intermodal relations and patterns of text coherence. Moreover, they can advise their peers on what kind of relations and attributes they should use. Overall, these parameters showed that teachers can be called as representational competent from now on.

Impacts of the MB-TTP on multimodal text design competence of teachers

It can be said that immersing learners in such a rich multimodal environment leads to an improvement in representational competence skills, especially in *identifying*, *selecting* and *defining* skills. The findings are in line with other studies in the literature (Keleş, 2016; McDermott & Hand, 2010, 2013; Hubber et al., 2010; Stieff, 2011; Tippett, 2016). In his study, Keleş (2016) stated that embedding multimodal representations in teaching methods had positive effects on students' understanding of multimodal representations. In another study, Stieff (2011) stated that the inclusion of such tools in the learning environment in chemistry courses improves students' ability to identify the properties of representations and explain why a particular representation is appropriate for a particular purpose. Hubber et al. (2010) also found that exposing students to a representation-rich learning environment improved students' representational competence.

Teachers' acquisition of representational competence may be linked to discussions about their multimodal designs. These discussions cover key aspects such as the features, structure, function, integration, and limitations of representations, all of which positively impact identification, analysis, and evaluation—core components of representational competence. Similarly, Daniellson and Selander (2016) found that meta-textual discussions on multimodal representations in science textbooks improved students' competence. Andersen and Munskby (2018) and Hubber and Tytler (2017) also reported that open discussions on modes enhanced students' ability to design and evaluate representations. Cooperative discussions, as emphasized by diSessa (2004) and Kozma and Russell (2005), further support these skills.

It can be said that this gradual increase in difficulty and decrease in scaffolding directly affected the development of essential representational skills, such as selection, design, translation, and evaluation. This, in turn, positively influenced other relevant skills.It can be argued that this process enhanced representational competence by motivating teachers through success and fostering autonomy through increased independence in learning.As stated by Waldrip et al. (2010), experiencing independency and being active in designing, manipulation, and revising multimodal representations; and also facing representational challenges played imperative roles in enhancing representational competence skills of students. Hubber and Tytler (2013) indicated that providing students with a sequence of representational challenges in the subject

of astronomy resulted in using representational vocabulary competently. The other reason for the development of representational competence could be that the model offered important opportunities in terms of transforming modes to each other. These transformations refer to the conversion of the available designs provided to them into a new representation according to their interests (Jewitt, 2003; Kress, 2010).

Intermodal transformation activities play a key role in design-oriented and multimodal teaching, as they encourage learners to reflect on the relationships between modes and their structures and functions. As a result, numerous design tasks were incorporated into all four micro-cycles. These activities are thought to enhance representational competence by immersing students in meaning-making processes (Kress & Selander, 2012; Selander, 2008). For example, Pérez Echeverría et al. (2010) found that providing students with frequent chances to switch between modes boosted their representational competence. Similarly, Waldrip and Prain (2012) suggested that progress in representational competence occurred through designers' efforts to integrate representations. Keles (2016) and Tippett (2011) also highlighted that multimodal teaching approaches involving transformation activities help students grasp multimodal representations better. Gunel et al. (2016) supported this, showing that non-traditional writing tasks, combined with various modes of representation, enhanced representational competence by offering learners opportunities to convert between modes. Additionally, explicit teaching of intermodal relations may further strengthen representational competence. For instance, Nam and Cho (2016) conducted an experiment where the experimental group, taught through a method emphasizing recognition of multimodal representations, outperformed the control group, which received direct instruction, in designing multimodal representations. Other studies (Chandrasegaran et al., 2008; Gee, 2005) reported similar findings. In conclusion, applying the MB-TTP framework, both theoretically and practically, across different contexts has shown positive effects on teachers' multimodal text design competence.

Conclusion

The model developed in this study can help teachers effectively use multimodal representations by focusing on intermodal mechanisms and text coherence to enhance teaching and learning. It provides a solid foundation for improving multimodal-based pedagogical strategies. Understanding the complementary relationship between different modes enables teachers to engage students more effectively and foster discipline-specific classroom discourse (Prain & Waldrip, 2006). Designing teaching processes based on these principles can contribute valuable insights for experimental research in various contexts (Fernandez-Fontecha et al., 2019).

By grasping the dynamic nature of multimodal representations, teachers can make informed decisions on selecting and designing materials that enhance student learning (Jaipal, 2010). This deeper understanding can improve teaching resources, classroom practices, and instructional methods (Tippett, 2011). Explicitly addressing intermodal relations and text coherence reduces misunderstandings caused by poorly designed

representations (Lim, 2018). Training programs that emphasize pedagogically specific intermodal relations can help teachers design suitable approaches for diverse students, including those who are gifted or need additional support.

This model can inform future research on learning with multimodal representations, integrating cognition, systemic functional linguistics (SFL), and multimodality (Tang et al., 2014). It serves as a preliminary step for further model development. With the increased use of multimodal representations in digital environments, this model can guide teachers in their instructional planning. Future studies should explore the model's effectiveness in improving representational competence for both teachers and students in various learning environments. Additionally, research is needed to refine measurement tools for representational competence, expanding beyond image and text to include modes such as gesture and spoken language.

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Unaprjeđenje programa za edukaciju učitelja darovitih učenika temeljenoga na multimodalnosti: istraživanje obrazovnoga dizajna

Sažetak

U ovoj studiji predstavljeno je istraživanje u obrazovnom dizajnu usmjereno na oblikovanje, implementaciju i evaluaciju multimodalnog programa obuke učitelja (MPOU) s ciljem unaprjeđenja vještina reprezentacijske kompetencije učitelja darovitih učenika (UDU). Cilj je bio opisati proces dizajna modela i razvoj UDU-a tijekom i nakon intervencije. Sudionici su odabrani metodom prigodnoga uzorka. Podatci su prikupljeni kroz multimodalne reprezentacije koje su osmislili učitelji, njihove komentare na te reprezentacije, rasprave o dizajnima i modelima u učionicama te intervjue sa sudionicima i stručnjacima. Prikupljeni podatci iz artefakata analizirani su prema analitičkom okviru koji je razvio istraživač. Intervjui i rasprave analizirani su putem analize sadržaja. Na kraju mikrociklusa 1 i 2, rezultati su pokazali da su učitelji stekli sposobnosti prepoznavanja, ali nisu bili osposobljeni za selekciju/dizajn i evaluaciju. Na kraju mikrociklusa 3 i 4, rezultati su otkrili da su učitelji bili sposobni prepoznati različite vrste intermodalnih mehanizama i svrhe njihovoga dizajna. Na kraju mikrociklusa 5, rezultati su pokazali da su učitelji bili sposobni identificirati i analizirati adekvatnost multimodalnih reprezentacija te kritički ocijeniti u kojoj mjeri reprezentacija odražava odnose između prikazanih modaliteta. Konačno, MPOU i njegovi dizajnerski principi identificirani su kao rezultat svih iteracija. Rezultati su otkrili da primjena MPOU-a i njegovih principa unapjređuje vještine reprezentacijske kompetencije kod UDU.

Ključne riječi: *istraživanje obrazovnoga dizajna, obrazovanje nadarenih, multimodalnost, edukacija učitelja, reprezentacijska kompetencija*

Uvod

Daroviti pojedinci razlikuju se od svojih vršnjaka visokim stupnjem kognitivnoga napretka (Renzulli, 1978). Posjeduju sposobnost brzog kodiranja složenih informacija u procesu razumijevanja (Clark, 2008), prepoznavanja i uspostavljanja uzročnih i

korelacijskih veza između pojmova (Sayı i Demir, 2016), iskustvenoga dubinskog učenja, samomotivirani su za učenje i djeluju neovisno (Sayı i Yurtseven, 2021). Izrazito su motivirani i predani zadatcima, održavajući pažnju i unutarnju kontrolu (Renzulli, 2003). Imaju iznimno pamćenje, bogatu i neobičnu maštu te širok vokabular (Miedijensky, 2018). Daroviti učenici pokazuju visoku razinu znatiželje i uživaju u visoko izazovnim procesima učenja (Syafril i sur., 2020). Aktivni su i kreativni u rješavanju problema te su sposobni prenositi svoja znanja u nove situacije (Altintas i Ozdemir, 2012; Betts i Neihart, 2010; Vogelaar i Resing, 2018).

Daroviti učenici uživaju i traže izazovne nastavne materijale i procese te rješavanje problema unutar obrazovnoga procesa (Phillips i Lindsay, 2006; Sayı i Yurtseven, 2021; Subotnik I sur., 2011; Taber, 2007). Prekomjerno ponavljanje osnovnih ideja, preopćenita objašnjenja, nedostatak detalja i izostanak izazova dovode do dosade i demotivacije (Taber, 2016). Gagne (2010) također naglašava da okružje za učenje bez adekvatnih izazovnih aktivnosti i sadržaja uzrokuje dosadu kod darovite djece. Drugi problem s kojim se daroviti učenici suočavaju u školi je nesposobnost nastavnika da zadovolje njihove obrazovne potrebe (Mammodow, 2019). Učenici u njegovoj studiji istaknuli su da njihovi nastavnici nemaju dovoljno pedagoškoga znanja za odgovarajuće prilagodbe u nastavi koje bi pružile adekvatan izazov.

Ukratko, problemi s kojima se suočavaju učenici mogu se klasificirati u tri kategorije: dosada, nedostatak izazova i neučinkovitost nastavnika. Posljednji problem vodi do loše osmišljenih aktivnosti, što uzrokuje dosadu, nezainteresiranost i demotivaciju jer ne pružaju dovoljan izazov. Svi su problemi međusobno povezani. Stoga se mnogi stručnjaci slažu da postoji velika potreba za diferenciranom pedagogijom, različitim nastavnim i obrazovnim aktivnostima, naprednim aktivnostima i dizajniranjem materijala koji izazivaju pozornost, znatiželju i kreativnost učenika (Hobden i sur., 2012; Housond, 2016; Stott i Hobden, 2016; Ulger i Irving, 2019; VanTassel-Baska i Wood, 2010).

Istraživači su predstavili različite modele kurikula za darovite učenike, uključujući Model obogaćivanja na razini škole (Reis i Renzulli, 2003), Model autonomnog učenika (Betts i Kercher, 2009), Purdueov trostruki model obogaćivanja (Moon i sur., 2009) i Integrirani kurikulski model (VanTassel-Baska i Wood, 2010). Ovi modeli naglašavaju dva ključna elementa za zadovoljavanje potreba darovite djece: diferencijaciju kroz akceleraciju i obogaćivanje. Akceleracija komprimira kurikul za brži akademski napredak, dok obogaćivanje pruža veću dubinu i raznolikost u iskustvima učenja (Davis i sur., 2014). Obogaćivanje prilagođava sadržaj, procese i okružje u skladu sa spremnošću, interesima i profilima učenja učenika (Tomlinson, 2005). VanTassel-Baska i Hubbard (2016) naglašavaju potrebu za obukom nastavnika u ovim strategijama diferencijacije.

Istraživanja pokazuju da, iako nastavnici prepoznaju potrebu za poticanjem viših kognitivnih vještina kao što su analiza, sinteza i evaluacija (Taber, 2007, 2014), mnogima nedostaje kompetencija za njihovu učinkovitu primjenu (Reis i Renzulli, 2003), a rijetki imaju naprednu certifikaciju u obrazovanju darovite djece (Chan, 2011). Oslanjanje na nastavne metode usmjerene na nastavnika, bazirane na udžbenicima i orijentirane prema

testovima, ograničava izazov za darovite učenike (Yuen, 2004). Stručnjaci zagovaraju okružja za učenje koja naglašavaju obogaćivanje i diferencijaciju (Coleman, 2014; Dilekli, 2017; Hong i sur., 2011). Stoga učitelji darovite djece (UDU) trebaju obuku u diferenciranoj pedagogiji kako bi povećali svoju učinkovitost i riješili probleme dosade i nedostatka izazova. Programi obrazovanja nastavnika trebali bi uključiti različite nastavne pristupe za razvoj ovih vještina.

U ovom kontekstu, istraživač ima za cilj osmisliti pedagoški model za UDU. Prije dizajniranja modela, provedena je analiza potreba kroz pregled literature, intervjue i analizu nastavnih materijala sudionika. Kada su problemi i potrebe identificirani, istraživač je tražio moguće rješenja te identificirao teorijske i praktične principe modela, proces učenja i poučavanja te vrste aktivnosti. Istraživanja su pokazala da multimodalnost i multimodalni pristup poučavanju i učenju nude mnoge mogućnosti za pružanje diferencirane pedagogije u obrazovanju darovite djece. Ovi pristupi opisani su u sljedećim odlomcima.

Multimodalnost

Multimodalnost, termin korišten u društvenoj semiotici, razvila se kao odgovor na paradigmatske promjene u društvenim i semiotičkim okvirima tijekom posljednjih nekoliko desetljeća (Jewitt, 2008a, b; Kress, 2009; Shannon, 2014). Ove promjene uključuju dvije glavne dimenzije: s jedne strane, slika zamjenjuje dugotrajnu dominaciju pisanih riječi, a s druge strane, ekran preuzima ulogu knjige (Selander, 2008). Slika i ekran postali su središnji izvori komunikacije (Bezemer i Kress, 2010).

Istraživanja o multimodalnosti otkrivaju nekoliko prednosti: poboljšava angažman učenika prema materijalima i konceptima (Fernandez-Fontecha i sur., 2019), potiče metarefleksiju o reprezentacijama (Andersen i Munksby, 2018), povećava interes i pažnju (Keleş, 2016) te podržava aktivno sudjelovanje i rješavanje problema (Cromley i sur., 2010; Kim, 2017). Multimodalnost potiče kreativnost u razvoju znanstvenih ideja (McDermott & Hand, 2013), podržava sintezu znanja kroz analizu različitih izvora (Wilson i Bradbury, 2016) te omogućuje učenicima predstavljanje koncepata u različitim oblicima, pojednostavljujući složeni diskurs (Taber i Akpan, 2016; Öz i Memiş, 2018). Fontecha i sur. (2019) navode da se putem multimodalnih reprezentacija, kao **što** su skice, apstraktna značenja u znanstvenim člancima transformiraju u konkretne oblike, a sažete se raščlanjuju. Tako se kompleksni oblik specijaliziranoga diskursa može pojednostaviti i dodatno obogatiti.

Uzimajući sve to u obzir, cilj je ovoga istraživanja razviti model slijeda aktivnosti učenja i poučavanja (pedagogije) osoba s intelektualim teškoćama. Stoga je, kao prvi korak, Multimodalni program obuke nastavnika (MPOU), s teorijskim i praktičnim načelima dizajna za obrazovanje darovitih, stvoren kroz istraživanje obrazovnoga dizajna. Model ima za cilj pružiti učiteljima darovitih učenika diferenciranu metodologiju poučavanja, sadržaj, aktivnosti i materijal, jer njihovi učenici zahtijevaju izazovne zadatke koji privlače njihovu pažnju i znatiželju, potiču vještine višega reda razmišljanja i omogućuju im

samostalnost u učenju. Na kraju, učitelji **će** biti kompetentni u dizajniranju multimodalnih tekstova. S tim u vidu, studijom se nastoji odgovoriti na sljedeća pitanja:

1. Kako je MPOU unaprijeđen?
2. Koja je početna i završna razina kompetencija nastavnika u dizajniranju multimodalnih tekstova?

Metodologija

Dizajn istraživanja

Metodološki okvir ovoga istraživanja temelji se na obrazovnom dizajnu istraživanja (DI). EDR ima za cilj ispitati moguća rješenja složenih obrazovnih problema u stvarnom kontekstu kroz sustavnu analizu dizajna i razvoja intervencije. DI doprinosi ne samo našem teorijskom znanju, već i znanju o praksi te obilježjima intervencije i procesima njezinoga dizajniranja i razvoja (Plomp, 2013). DI uglavnom se fokusira na to kako obrazovanje može ili čak kakvo bi trebalo biti (Bakker, 2018). To znači da istraživači u obrazovanju imaju želju riješiti problem s kojim su se susreli. U DI-u istraživanje i dizajn su isprepleteni i međusobno ovisni. Dizajniranje nastavnih materijala ili programa profesionalnoga razvoja ispremiće se s iterativnim ciklusima testiranja i poboljšanja teorije, ili obrnuto (Bakker, 2018). Naime, dizajn testira i razvija teoriju u različitim kontekstima, a razvijena teorija vodi do stvaranja novih dizajna. Općenito, D obuhvaća tri faze istraživanja: (1) preliminarnu fazu istraživanja, (2) fazu prototipa ili razvoja i (3) fazu evaluacije (Nieveen i Folmer, 2013; Plomp, 2013).

Sudionici

Sudionici su odabrani iz Centara za znanost i umjetnost (CZU) putem prigodnoga uzorka. CZU-i su javne škole koje služe darovitim učenicima kao izvannastavni programi. Ove škole imaju za cilj zadovoljiti obrazovne potrebe darovite djece u mlađim i starijim razredima primarnog obrazovanja, i srednjim školama kroz dodatni rad i rad u skupiinama (Sak, 2010). U tim školama bio je jedan ili dva nastavnika prirodnih znanosti. Oni su u ovom istraživanju sudjelovali putem online i sastanaka uživo. Na tim su sastancima jasno objašnjeni proces i ciljevi istraživanja, uloge i odgovornosti istraživača i provoditelja, što se od njih očekuje te vremenski okvir istraživanja. Također su obaviješteni o ciljevima koje će postići na kraju procesa, kako će se ostvariti suradnja između istraživača i praktičara te o opsegu, sadržaju i rezultatima istraživanja.

Četiri UDU dobrovoljno su pristala sudjelovati u ovom istraživanju. Dvojica su muškarci, a dvije su žene. Jedan od njih ima diplomu, dvoje magisterij, a jedan doktorat. Svi su iskusni u poučavanju prirodnih znanosti darovite djece, s prosjekom radnoga staža od 7 godina. Rade u različitim regijama Turske.

Prikupljanje i analiza podataka

U ovom istraživanju korišteni su kvalitativni podatci za ispitivanje poboljšanja programa obuke nastavnika i razvoja vještina reprezentacijskoga dizajna UDU-a tijekom i nakon izloženosti MPOU-u. Polustrukturiranim intervjuima provedenim sa sudionicima i

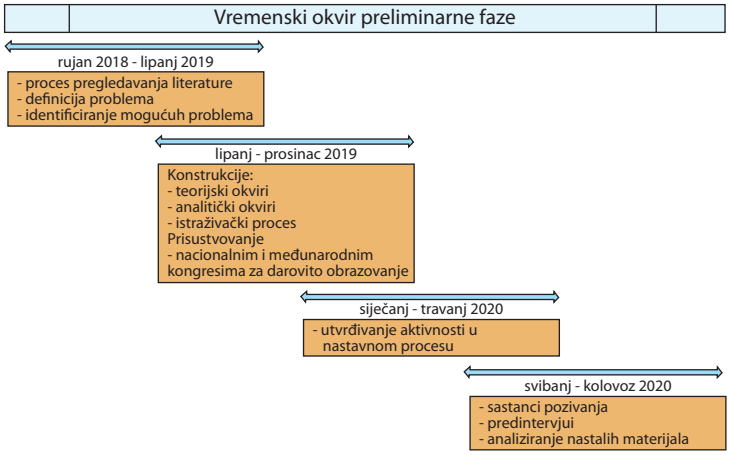
stručnjacima ispitali su njihovi pogledi i percepcije modela, proces poučavanja i učenja te aktivnosti. Predstavljanja nastavnika provedena u svakoj fazi također su dokumentirana kako bi se pratilo njihovo napredovanje.

Intervjui i diskusije analizirani su kvalitativno putem analize sadržaja. Podatci su kodirani, kategorizirani i na kraju su identificirane teme (Savin-Baden i Major, 2023). Podatci dobiveni iz artefakata koje su sudionici izradili analizirani su prema razvijenom analitičkom okviru (Gül i Costu, 2021). Okvir se temelji na sustavnoj funkcionalnoj multimodalnoj diskurzivnoj analizi. Na temelju analitičkoga okvira, međumodalni odnosi između slike i teksta klasificirani su u dvije grupe, četiri razine i osam kategorija. Dvije grupe odnose se na sukladnost i komplementarnost. Prva uključuje dvije razine (Razina 1 i 2) i četiri kategorije (dekorativna, primjerna, reprezentacijska i ekspozicijska). Druga također uključuje dvije razine (Razina 3 i 4) i četiri kategorije (komparativna, organizacijska, augmentacijska i interpretativna).

Postupak istraživanja

Preliminarna faza

U ovoj fazi, cilj istraživača bio je najprije utvrditi probleme s kojima se UDU susreću u stvarnom obrazovnom kontekstu u vezi s korištenjem i dizajniranjem multimodalnih reprezentacija. Da bi to učinio, prikupljene su i analizirane pojedinačne reprezentacije nastavnika kako bi se utvrdilo jesu li reprezentacijski kompetentni. Potom je istraživač proveo jednogodišnji pregled literature kako bi definirao problem, identificirao moguća rješenja te aktivnosti poučavanja i učenja, odlučio o teorijskim i konceptualnim okvirima studije, uspostavio model intervencije te principe i analitičke okvire (Slika 1). Tijekom te godine, istraživač je također sudjelovao na nacionalnim i međunarodnim akademskim skupovima vezanim uz obrazovanje darovite djece. Istraživač je otkrio da nisu postojali pokušaji i studije za dizajniranje pedagoškoga modela kako bi UDU postali reprezentacijski kompetentni.

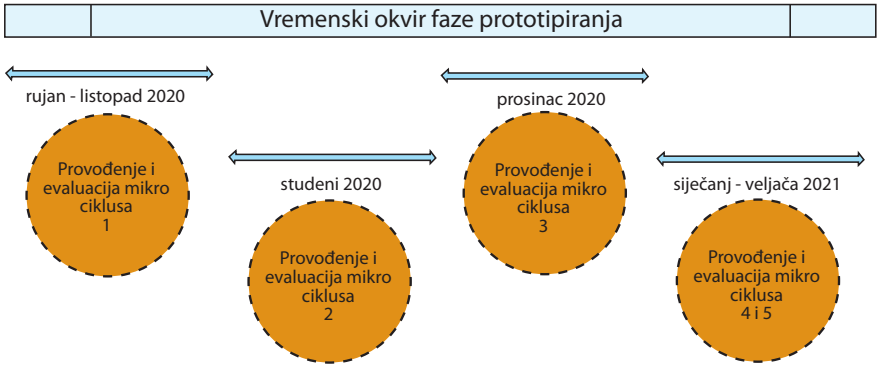


Slika 1. Vremenska crta preliminarne faze

Na kraju svih ovih procesa, istraživač je razvio konceptualni ili teorijski okvir istraživanja, identificirao teorijska i praktična načela te naposljetku dizajnirao nacrt modela za intervenciju (Bakker, 2018; Plomp, 2013). Drugim riječima, na kraju preliminarne faze, pojavio se nacrt modela s nizom nacrta načela dizajna za rješavanje problema.

Faza prototipiranja

Faza prototipiranja drugi je korak DI-a. Ona uključuje iterativne primjene nacrta modela, ili drugim riječima mikrocikluse (Slika 2). Svaki mikrociklus podvrgnut je formativnoj evaluaciji kako bi se intervencija mogla revidirati i razvijati. U ovom istraživanju provedeno je pet mikrociklusa kako bi se dobio snažan model koji može poboljšati reprezentacijsku kompetenciju UDU-a u istraživanju. U svakom mikrociklusu, UDU su koristili različita interaktivna okružja za učenje (Seesaw, Google Classroom, Thinglink, Piktochart i dr.). Stoga je, na kraju petoga mikrociklusa istraživač zaključio da se intervencija razvila u učinkovit model za razvoj kompetencija UDU-a u dizajniranju multimodalnih tekstova.



Slika 2. Vremenska crta faze prototipiranja

Faza evaluacije

U ovoj fazi provedena je retrospektivna analiza od početka preliminarne faze do kraja faze razvoja. Pojedinačni procesi sudionika i analiza modela intervencije procijenjeni su kao cjelina iz sveobuhvatne perspektive. Na taj se način istraživanjem prikazala konačna verziju modela intervencije i njegove daljnje implikacije.

Rezultati

Preliminarna faza

Rezultati su pokazali da UDU nemaju dovoljnu stručnost u korištenju, odabiru i dizajniranju visokoga stupnja multimodalnih reprezentacija (Slika 3). Ovi su podatci ukazali na to da nastavnici imaju ograničeno eksplicitno znanje o intermodalnim odnosima u multimodalnim reprezentacijama. Rezultati su također pokazali da UDU imaju ograničeno znanje o tome kako koristiti različite vrste reprezentacija u pedagoške svrhe u digitalnom ili stvarnom učioničkom okružju (Slika 3). Neki primjeri reprezentacija

koje su nastavnici koristili prije intervencije prikazani su u Tablici 1. Na kraju preliminarne faze, istraživač je također unaprijedio teorijska i praktična načela nacrta MPOU-a.

Slika 3

Tablica 1
Nekoliko primjera multimodalnih tekstova prije intervencije

• **Primjer zakona inercije** • Kada putujemo automobilom i automobil koči, a mi se pomičemo naprijed. • Pomicanje unatrag kada automobil kreće iz mirovanja. • Kada protresamo mokre ruke, voda prska posvuda. • Kretanje rakete lansirane u svemir.	Monomodal Tekst (primjeri zakona inercije) uključuje samo pisani način.
 Znanstvene metode Niz koraka koje znanstvenici koriste u rješavanju ili odgovaranje na problem. Koraci znanstvene metode • Promatranje • Hipoteza • Dizajn eksperimenta • Analiza • Zaključak	Primjer Dok tekst objašnjava što je znanstvena metoda i koji su njezini koraci, vizualni prikaz daje samo naznaku o dijelu promatranja.

The MPOU. Cilj je dizajniranja ovoga modela ponuditi katalizator okružja za razvoj specifične kompetencije kod UDU-a, nazvane kompetencija dizajna multimodalnoga teksta. Ova kompetencija omogućuje UDU-u da osmisli izazovne materijale za poučavanje i učenje darovitih učenika. Stoga je MPOU kreiran uzimajući u obzir kako se proces poučavanja i učenja odvija na multimodalan način. Proces poučavanja u okviru MPOU-a objašnjen je uzimajući u obzir Peirceov trostruki odnos između znaka, objekta i tumača, Robertov (1996) trialog i parametre društveno-semiotičke teorije: semiotički sustav, tekst i izbor (interes). Istraživanje objašnjava ove triade na temelju Waldripove isprepletene trijade (2010) (Slika 4). Ova se trijada temelji na Peirceovom trokutastom modelu stvaranja značenja. Prema ovom okviru, proces učenja uključuje elemente „koncepta učitelja (KU)", „reprezentacije učitelja (RU)", „koncepta učenika (KUC)" i „reprezentacije učenika (RUC)". Svaki par tvori Peirceov esej značenja s „domenom (D)", sadržajem koji se poučava/uči. Drugim riječima, poučavanje i učenje je dinamičan ciklički proces 'dizajniranja' između domene koja se poučava (D), reprezentacija učitelja (RU), koncepta učitelja (KU), reprezentacija učenika (RUC) i koncepta učenika (KUC) (Waldrip i sur., 2010).

Slika 4

Budući da se istraživanjem tvrdi da je učenje dizajn, objašnjava se kako se uči kroz multimodalne reprezentacije i kako bi procesi učenja trebali biti organizirani kao proces poučavanja, prilagođavajući radove *New London Group* (1996), Robertov (1996) trijalog, Okvir za dizajn (Cope i Kalantzis, 2015) i Dizajn za učenje (Selander i Kress, 2012). Drugim riječima, objašnjava se kako je proces poučavanja oblikovan prema koracima

učenja i kako dolazi do učenja. Ovo istraživanje podržava proces poučavanja u okviru istih principa *New London Group*, ali s prilagodbama prema studijama Cope i Kalantzis (2015), Selander i Kress (2012) te Lim (2018). Sve četiri faze modela spomenutoga u nastavku operacionalizirane su u skladu s ovim studijama.

Dizajniranje pedagoškoga okružja (DPO). U ovoj fazi učitelj uvodi učenike u semiotički bogato okružje sa smislenim aktivnostima nudeći razne dizajne koji odražavaju poznata i nova iskustva (Jewitt, 2008; Lim, 2018). Ovi dostupni dizajni, koje učitelj podržava, trebaju balansirati između poznatoga i novoga (Cope i Kalantzis, 2015). Oni mogu uključivati standardne kurikule poput udžbenika i radnih bilježnica, kao i složenije materijale prilagođene stručnosti učenika (Selander, 2008).

Dostupni dizajni obuhvaćaju definirani kurikul i dodatne materijale koji obogaćuju iskustvo učenja u smislu dubine, raznolikosti i težine. Ovi materijali mogu uključivati udžbenike, radne bilježnice te napredne multimodalne izvore poput infografika, animacija i videozapisa. Kompetencija učitelja u dizajnu multimodalnoga teksta ima ključnu ulogu, omogućujući mu odabir ili dizajniranje najprikladnijih reprezentacija kako bi se učenicima olakšalo razumijevanje sadržaja. Ova kompetencija uključuje svijest o međumodalnim mehanizmima i sposobnost dizajniranja materijala koji angažiraju učenike i podržavaju njihovu interpretaciju. Ovaj korak služi kao pripremna faza poučavanja, u kojoj učitelj interno (teorijski) i eksterno (praktično) dizajnira okružje i procese učenja na temelju učenikovih potreba. Učitelj određuje kako će se znanje oblikovati i transformirati, informira učenike o ključnim konceptima, očekivanim ishodima i kriterijima vrednovanja (Selander, 2008).

Proces uključuje tri ključna elementa: reprezentaciju učenika, interese i percepcije. Učitelji stvaraju prilike za učenike da generiraju, usavršavaju i revidiraju svoje reprezentacije, potičući aktivan i istraživački proces učenja. Aktivnosti su dizajnirane tako da odražavaju interese i vrijednosti učenika te moraju imati snažan perceptivni kontekst koji podržava smislenu angažiranost.

Poučavanje metajezika (PM). Ova faza započinje predstavljanjem izazova u učiteljevoj reprezentaciji koji uključuje zadatak u skladu s interesima učenika, odnosno u kojem se učenici potiču da izvrše složenije zadatke nego što bi ih mogli ostvariti sami. Takva situacija dovodi do suradnje između učitelja i učenika i čini ih oboje aktivnima. Tijekom suradnje, učenici stječu svijest o reprezentaciji učitelja i korištenju metajezika, koja se odnosi na unutarnje i međumodalne mehanizme unutar i između modusa (New London Group, 1996). Koherentne multimodalne reprezentacije učitelja motiviraju i potiču učenike na izvršavanje složenih zadataka (Forsling, 2019). PM je ključna pedagoška strategija u kojoj učenici uče prepoznati dizajnerske elemente, usvajaju sustavno znanje o analitičkom vokabularu u stvaranju značenja te kako se modusi usklađuju u konstrukciji multimodalnih reprezentacija (Cope i Kalantzis, 2015; Jewitt, 2008; Lim, 2018).

Tako učenici osvješćuju mogućnosti i ograničenja učiteljeve reprezentacije i upotrebu metajezika koja se odnosi na unutarnje i međumodalne mehanizme unutar i između modusa (New London Group, 1996). Tijekom procesa prepoznavanja, učitelj obraća

pozornost na eksplicitne upute o sljedećem: (1) obliku i funkciji modusa ako započinje novu reprezentaciju, (2) kako se funkcija modusa ostvaruje njegovim oblikom, (3) kako reprezentacija kodira i predstavlja informacije, (4) kako su informacije raspodijeljene među modusima koji se mogu međusobno nadopunjavati ili ograničavati te (5) uvođenju različitih vrsta međumodalnih mehanizama (sukladnost i komplementarnost).

U PM-u, domena (koherentne i smislene multimodalne reprezentacije) i reprezentacijski izazov koji predstavlja učitelj postaju skup svih novih dostupnih dizajna za učenike (D). Učitelji uvode metajezik/međumodalne mehanizme multimodalnih reprezentacija (RU), a zatim učenici konstruiraju svoje nove koncepcije/novu shemu u svojem umu/interno (KUC). Na spoju eksplicitnih uputa i kritičkoga oblikovanja, nastavlja se unutarnji dizajn.

Kritičko oblikovanje (KO). Učenici prvo stvaraju svoj unutarnji dizajn analizom reprezentacija koje je pripremio učitelj, a zatim transformiraju poznate reprezentacije u nove, u kontekstima u koje je problem smješten, koristeći se usvojenim metajezikom. Osim toga, učenici promišljaju o svojem konceptualnom razumijevanju, dizajnu i oblikovanju (Kress i Selander, 2012). U ovom koraku, učenici integriraju nove sheme s postojećim shemama u dugoročno pamćenje putem internalizacije. Kritičko oblikovanje uključuje dva osnovna koraka: analizu i internalizaciju putem dizajna.

Analiziranje uključuje uspostavljanje logičkih veza poput dedukcije i indukcije, proces zaključivanja te uspostavljanje funkcionalnih odnosa kao što je uzročnost. Proces se funkcionalno ostvaruje analizom strukture, funkcije, konteksta znanja i načina na koji se znanje prezentira. Učenici sami sebi postavljaju pitanja i analiziraju tekstove iz pedagoške literature: što to radi? kako to radi? koja je struktura, funkcija, odnosi i kontekst? (Cope i Kalantzis, 2015; Lim, 2018). Proces internalizacije znači da dizajner stvara konačnu shemu u svojem umu ispitivanjem i analiziranjem multimodalnih tekstova koje je pripremio učitelj, prema vlastitim interesima i preferencijama. Kritičko oblikovanje je temelj za transformiranu praksu jer ovaj proces pomaže dizajnerima postići izvrsnost u dizajniranju, analizi, svjesnoj kontroli i razumijevanju.

Transformirana praksa (TP). U ovom procesu učenici „denaturaliziraju" i „otuđuju" ono što su već naučili. Pred njima je novi reprezentacijski izazov u različitim kontekstima, pri čemu se od njih traži da rekreiraju i rekontekstualiziraju značenje kroz različite kontekste (Jewitt, 2008). U određenom smislu, transformirana praksa ponovno pokreće proces poučavanja i vraća nas na početak.

Dizajner primjenjuje ono što je naučio i prilagođava iskustveno, kritičko i konceptualno znanje iz jednoga konteksta u drugi (Lim, 2018). Ukratko, napuštajući trenutačni kontekst, učenici su suočeni s novim zadatkom i traži se da ga primijene u novom kontekstu kako bi pokazali funkcionira li reprezentacija u novim uvjetima. Time se ciklus poučavanja ponovno pokreće. Kako Kress kaže: „…angažman putem transformativnog djelovanja, koje neprestano obnavlja moje unutarnje resurse i time mijenja moj potencijal za buduće djelovanje u svijetu i na svijet." (Kress, 2010, str. 14).

U DPE fazi učitelj odabire ključne koncepte (domena) koje će poučavati, oblikuje unutarnje reprezentacije birajući između svih dostupnih opcija dizajna (TC) te

konstruira vanjske reprezentacije (RU), analizirajući njihovu prikladnost i kompetenciju. Zatim planira kako ih prezentirati, uzimajući u obzir dva važna obrasca: (1) smanjenje opterećenja vanjskih elemenata i povećanje/smanjenje unutarnjega opterećenja prema razini stručnosti učenika, (2) dizajniranje procesa reprezentacijskoga izazova. U PM-u, domena (koherentne i smislene multimodalne reprezentacije) i reprezentacijski izazov koji predstavlja učitelj postaju skup svih novih dostupnih dizajna za učenike (D). Učitelji uvode metajezik/međumodalne mehanizme multimodalnih reprezentacija (RU), a učenici zatim konstruiraju svoje nove koncepcije/nove sheme u svojem umu/interno (KUC). Na spoju PM-a i KO-a unutarnji dizajn se nastavlja. Na kraju KO-a učenici oblikuju svoje vanjske reprezentacije kombiniranjem postojećih shema s novim shemama (RUC). U transformiranoj praksi učenici su uronjeni u novi kontekst (D). Prema potrebama novoga konteksta, konstruiraju svoje koncepcije (SR).

Ukratko, (1) učitelji prvo interno dizajniraju multimodalne reprezentacije, zatim eksterne (nastavne materijale), (2) predstavljaju ih učenicima, (3) učenici razumiju te tekstove i oblikuju ono što su naučili kao multimodalni tekst u svojem umu, (4) zatim dizajniraju produkt učenja multimodalno kako bi pokazali što su naučili, (5) na kraju učitelji ocjenjuju te produkte i daju povratne informacije.

Faza prototipiranja

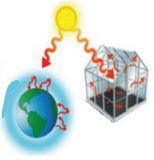
Mikrociklus 1

Rezultati su pokazali da su svi sudionici stekli sposobnost odabira i integriranja prikladnih slika i tekstova iz dostupnih materijala koje je osigurao istraživač. Drugim riječima, bili su vješti u pronalaženju i odabiru odgovarajućih materijala iz dostupnih opcija. Važno je napomenuti da su sudionici dizajnirali sve vrste međumodalnih odnosa, iako je većina njihovih reprezentacija pripadala kategoriji na osnovnoj razini (razine 1 i 2) (Sl. 5 i Tablicu 2). Odabirali su dizajniranje visoko razinskih multimodalnih reprezentacija (razine 3 i 4), ali rijetko su koristili nadogradnju i interpretaciju.

Slika 5

Tablica 2

Nekoliko primjera multimodalnih tekstova u mikrociklusu 1

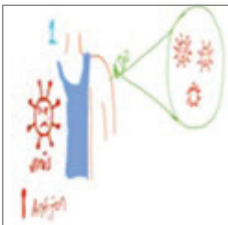
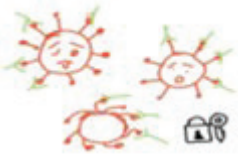
 Staklenički plinovi i globalno zagrijavanje Zemljina atmosfera (sloj plinova) propušta sunčeve zrake i apsorbira dio njih.	Reprezentacijski Izjava u tekstu (Zemljina atmosfera (sloj plina) propušta sunčeve zrake i apsorbira dio njih.) odražava se u slici.
i staklenički plinovi u atmosferi  Staklenik prima toplinu od sunca tijekom dana.	Usporedni Tekst i slika zajedno omogućuju čitateljima razumijevanje sličnosti i razlika između staklenika i stakleničkih plinova u atmosferi.

Mikrociklus 2

U ovom koraku, iako je istraživač sudionicima dao samo polovicu dostupnih izvora (svi izvori bili sun a raspolaganju) i, za razliku od prethodnoga koraka, pružio povratne informacije temeljene na postavljanju pitanja umjesto objašnjenja, rezultati su pokazali da se njihov dizajn razvijao s razina 1 i 2 na razine 3 i 4 (Sl. 6 i Tablicu 3). Međutim, jasno je da, iako su učitelji imali mnogo prilika za oblikovanje komparativnih, organizacijskih, nadogradnih i interpretacijskih odnosa kako bi nadopunili poluzavršeni infografik, nisu ih iskoristili. S obzirom na sve ove nalaze, može se zaključiti da su se vještine oblikovanja reprezentacija kod UDU-a blago poboljšale tijekom procesa i u usporedbi s prethodnom aktivnošću dizajna.

Slika 6

Tablica 3
Nekoliko primjera multimodalnih tekstova u mikrociklusu 2

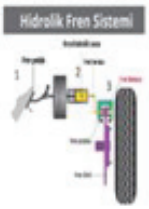
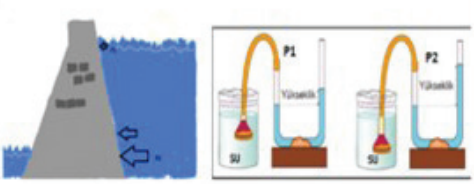
 Oslabljeni ili mrtvi virus unosi se u tijelo zajedno s nekim tekućinama u cjepivu. Kada klice uđu u tijelo, naš imunološki sustav ih prepoznaje i pokušava ih eliminirati. To čini prepoznavanjem antigena.	Izlaganje Oslabljeni virusi prikazani su kao emojiji u istoj općenitosti. Slika i tekst odražavaju isto značenje, ali s različitim semiotičkim izvorima.
 Svako antitijelo prepoznaje antigene koji okružuju virus i često se vežu za ciljani antigen.	Dopuna Simbol ključa i brave na slici prikazuje se kao ciljani antigen u tekstu.

Mikrociklus 3

Na kraju aktivnosti dizajna u mikrociklusu 3, iako je razina potpore smanjena te su učitelji dobili povratne informacije temeljene na istraživačkom pristupu, vještine dizajna sudionika su se poboljšale u usporedbi s prethodnim mikrociklusom. Povećan je broj i raznolikost visokorazinskih multimodalnih prikaza (Sl. 7 i Tablicu 4). Nalazi su pokazali da su učitelji razvili sposobnosti odabira i kombiniranja prikladnih slika i tekstova koje sami pronalaze u dostupnim izvorima u digitalnom i stvarnom okružju za učenje. Ukratko, zaključeno je da su sudionici-pedagozi u ovom mikrociklusu poboljšali vještine višerazinskoga reprezentacijskog dizajna zajedno s vještinom odabira.

Slika 7

Tablica 4
Nekoliko primjera multimodalnih tekstova u mikrociklusu 3

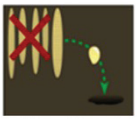
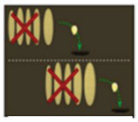
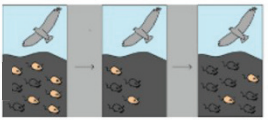
 **Hidraulički sustav kočnica** Hidrauličke kočnice koriste tlak hidrauličkog ulja za upravljanje kočnim organima vozila. 1.Kada se primjeni sila na papučicu kočionog sustava, klip glavnog cilindra stvara tlak. 2. Taj tlak dolazi do kotačnih cilindara kroz cijevi. 3. Kočenje se postiže otvaranjem klipova kotačnih cilindara. Tlak koji djeluje na središnju pumpu kočnica prenosi se jednako na sve kotačne cilindre.	Organizacijski Slika i tekstovi zajedno pokazuju kako hidraulički sustav radi dijeljenjem značenja.
Zašto su donji dijelovi brana izgrađeni deblje? 	Interpretacijski Odgovor na pitanje zašto je donji dio zidova brane deblji traži se rješavanjem s drugom slikom putem uzročno-posljedičnih odnosa.

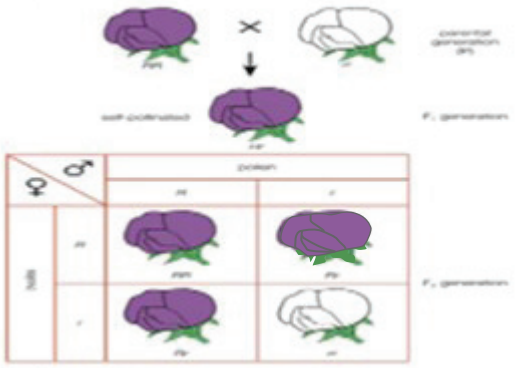
Mikrociklus 4

Na kraju aktivnosti dizajna u mikrociklusu 4, vještine dizajna kod UDU-a poboljšale su se u usporedbi s prethodnim mikrociklusom. Povećani su broj i raznolikost visokorazinskih multimodalnih prikaza. Nalazi su pokazali da su učitelji poboljšali sposobnosti odabira i integracije prikladnih slika i tekstova koje sami pronalaze iz bilo kojega dostupnog izvora u digitalnom i stvarnom okružju za učenje (Sl. 8 i Tablicu 5). Sudionici-pedagozi oblikovali su gotovo sve vrste multimodalnih prikaza uzimajući u obzir elemente intermodalnih odnosa. Stoga ih se može smatrati kompetentnima u reprezentacijskom smislu **što** se tiče vještina odabira (identifikacije) i oblikovanja.

Slika 8

Tablica 5
Nekoliko primjera multimodalnih tekstova u mikrociklusu 4

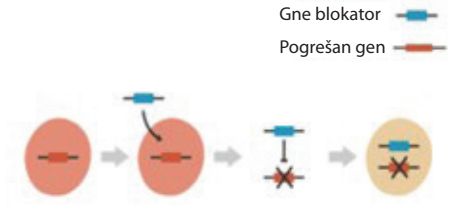
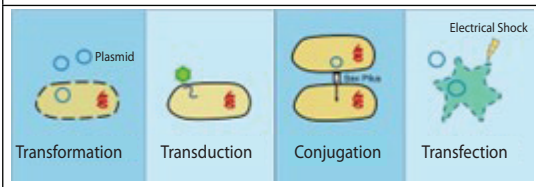
1 Umjetna selekcija i prirodna selekcija  **2** Prirodna selekcija se događa  **3** Ljudi biraju najbolje osobine za sljedeću generaciju.  **4** Ovaj se proces ponavlja mnogo puta.  **5** S vremenom se kvalitata proizvoda poboljšava.  **6** U umjetnoj selekciji, organizmi bez otpornosti nestaju nakon nekog vremena.	Usporedni Slike i tekst traže od čitatelja da usporedi i razumije razlike između prirodne selekcije i umjetne selekcije.

Kako možemo koristiti umjetnu selekciju?  Kako dobiti usjeve s novim osobinama na temelju genetskih osnova ponašanja. Možete razmišljati u smislu Mendelovih križanja.	Interpretacijski Slika i tekst traže od čitatelja da uspostavi uzročno-posljedičnu vezu između Mendelovih križanja i umjetne selekcije

Mikrociklus 5

Na kraju aktivnosti dizajna u mikrociklusu 4, vještine dizajna kod UDU-a dodatno su se poboljšale u odnosu na prethodni mikrociklus. Povećan je broj i raznolikost visokorazinskih multimodalnih prikaza. Nalazi su pokazali da su učitelji poboljšali sposobnosti odabira i integracije prikladnih slika i tekstova koje sami pronalaze iz bilo kojega dostupnog izvora u digitalnom i stvarnom okružju za učenje (Tablica 6). Sudionici-pedagozi oblikovali su gotovo sve vrste multimodalnih prikaza uzimajući u obzir elemente intermodalnih odnosa. Stoga ih se može smatrati kompetentnima u reprezentacijskom smislu **što** se tiče vještina odabira (identifikacije) i oblikovanja.

Tablica 6
Nekoliko primjera multimodalnih tekstova u mikrociklusu 5

 Terapija smanjenjem gena: Kada se gen blokator unese u stanicu koja sadrži neispravan gen, stanica funkcionira normalno.	Dopuna je korištena kao intermodalni odnos. Terapija smanjenja gena modelirana je s novim ikonama. Također uključuje izlaganje. Slabo/osrednje/**dobro** zadovoljava gore navedene intermodalne odnose.
 Kako bakterije postaju otpornije?	Interpretacijski je korišten kao intermodalni odnos. Također uključuje usporedne elemente. Slabo/**osrednje**/dobro zadovoljava gore navedene intermodalne odnose

Mikrociklus 5 proveden je kao vježba za provjeru jesu li sudionici-pedagozi kompetentni u reprezentacijskom smislu što se tiče svojih vještina evaluacije budući da su do sada evaluirali samo svoje multimodalne prikaze. Stoga je istraživač učiteljima predočio matricu za evaluaciju te ih zamolio da procijene bilo koji multimodalni artefakt svojih kolega. Podatci pokazuju da ToG ima sposobnost identificiranja intermodalnih odnosa i procjene u kojoj mjeri oni postoje. Osim toga, davali su prijedloge svojim kolegama o tome kakve bi vrste odnosa i tekstualnih kvaliteta trebali koristiti.

Faza evaluacije

U istraživanju temeljenom na dizajnu, proces evaluacije provodi se kroz samo istraživanje. Evaluacija mikrociklusa provodi se kako bi se pratilo razvijanje vještina sudionika i usavršio model kao rezultat provedene intervencije tijekom i nakon procesa. Na temelju podataka dobivenih iz ovih evaluacija, donose se zaključci o dizajnerskim principima modela intervencije i samom modelu.

Rezultati evaluacije mikrociklusa 1 i 2

Kao što je naznačeno u dijelu s rezultatima, kada su svi slučajevi analizirani pojedinačno i sve osmišljene reprezentacije sagledane u cjelini (Sl. 9), primijećeno je da je porasla sklonost učitelja prema korištenju različitih tipova intermodalnih odnosa. Podatci su također pokazali da je povećan broj visokorazinskih intermodalnih odnosa koje su sudionici koristili. Međutim, još je prerano tvrditi da su postigli reprezentacijsku kompetenciju jer su kreirali niže razine intermodalnih mehanizama u aktivnostima 3 i 4, iako su svi dostupni tekstovi i vizuali osigurali istraživači.

Slika 9

Ostali razlozi zašto se ne smatraju reprezentacijski kompetentnima mogu se navesti na sljedeći način. Prvo, učitelji su imali poteškoća u oblikovanju komparativnih, organizacijskih, augmentacijskih i interpretativnih odnosa. Drugim riječima, nisu bili sposobni učinkovito koristiti visoke razine intermodalnih odnosa. Drugi je razlog što nisu iskoristili mogućnost korištenja odgovarajućih intermodalnih odnosa, iako je ta mogućnost bila omogućena kroz teme.

Ukratko, učitelji su mogli identificirati te intermodalne odnose kroz diskusije, no povremeno se vidjelo da ih još uvijek ne mogu primijeniti jer ih nisu prepoznali u potpunosti. Ipak, na temelju svih prikupljenih podataka, može se tvrditi da su sudionici postajali sve vještiji u uspostavljanju visokih razina intermodalnih odnosa. To ukazuje na to da MPOU može biti učinkovit u povećanju reprezentacijske kompetencije sudionika. Ipak, potrebne su određene dorade i poboljšanja. Stoga je istraživač odlučio provesti poboljšanja modela u suradnji sa stručnjacima i učiteljima sudionicima. Diskusije sa stručnjacima i učiteljima sudionicima otkrile su potrebu za četiri glavna poboljšanja u modelu i procesu implementacije. Predložena poboljšanja i dodatci odnose se na izazove u reprezentaciji, razinu podrške, samoprocjenu, medij primjene i otvoreno poučavanje.

Rezultati evaluacije mikrociklusa 3 i 4

Prilikom istraživanja svih slučajeva pojedinačno, kako je navedeno u dijelu s rezultatima i analiziranjem svih dizajniranih reprezentacija u cjelini (Sl. 10), povećana je sklonost učitelja prema korištenju različitih vrsta intermodalnih odnosa. Podatci su također pokazali da se povećao broj visokih razina intermodalnih odnosa koje su sudionici koristili. Međutim, još uvijek je prerano tvrditi da su reprezentacijski kompetentni jer su konstruirali niže razine intermodalnih mehanizama u aktivnostima 3 i 4, unatoč tome što su istraživači osigurali sve dostupne tekstove i slike.

Slika 10

Kao što se vidi na Slici 10, unaprjeđenja i njihova primjena na model utjecali su na korištenje visoke i niske razine intermodalnih odnosa. Iako reprezentacije iz petog slučaja značajno utječu na omjere, postotak i broj visokih razina odnosa se povećao (52 % - 66 % - 68 %; 27 – 33 - 40), dok su postotak i broj niskih razina smanjeni (48 % - 36 % - 32 %; 25 – 19 - 19).

Rasprave sa stručnjacima i učiteljima sudionicima pokazale su da se dva važna aspekta također trebaju naglasiti kako bi model bio sveobuhvatniji. Prvo, potrebno je omogućiti interakciju među sudionicima. Tako se može obogatiti pedagoško okružje i osnažiti otvoreno poučavanje jer sudionici imaju priliku vidjeti nove tipove multimodalnih reprezentacija kao dostupne dizajne. Primjerice, učitelj T2 izjavio je:

„Na primjer, zanima me što su drugi prijatelji napravili, voljela bih vidjeti njihove reprezentacije, budući da postoji još nekoliko izvora, više učite od prijatelja ili izvora u tom smislu."

Učitelj T3 također je naveo:

„I ja se pitam što su drugi napravili, gledanje njihovih reprezentacija može mi pomoći da učim i vidjela bih više izvora o tim odnosima."

Drugi aspekt koji su istaknuli stručnjaci jest taj da nije dovoljno da sudionici evaluiraju samo vlastite reprezentacije. Trebaju također procijeniti reprezentacije vršnjaka u različitim kontekstima. Takko se preciznije utvrđuje jesu li reprezentacijski kompetentni ili nisu. Ovo također jača kritički okvir. Primjerice, Stručnjak 3 izjavio je:

„U prethodnom procesu analizirali su samo svoje reprezentacije, što je važna točka kako bi se vidjelo jesu li napravili svjestan odabir. Još jedna stvar jest da sudionici nisu dizajnirali neke intermodalne odnose, ne možete utvrditi prepoznaju li te intermodalne odnose ili ne. Stoga, analiza reprezentacija drugih osoba pružit će nam potpunije informacije. Može se dodati i evaluacija vršnjaka."

Na temelju mikroevaluacije 2, istraživač je unaprijedio model dodavanjem dijela za prezentaciju, pri čemu su sudionici predstavljali svoje dizajne vršnjacima. Tako se nastojalo poboljšati interakciju među sudionicima. Osim toga, uveden je pregled vršnjaka radi obogaćivanja dijelova transformirane prakse i kritičkoga okvira.

Rezultati evaluacije mikrociklusa 5

Analiza sudionika o intermodalnim odnosima i njihovi komentari o reprezentacijama otkrili su da su bili sposobni prepoznati intermodalne odnose. Nalazi su pokazali da su ne samo analizirali, već i kritički ocijenili u kojoj mjeri reprezentacija odgovara navedenim intermodalnim odnosima. Nadalje, savjetovali su svoje kolege o tome koje vrste odnosa koristiti. Njihovi odgovori na pitanja u intervjuu također su bili u skladu s reprezentacijama koje su dizajnirali i njihovim analizama. Ovi parametri pokazuju da su također stekli analitičke vještine i kritičku perspektivu o tome koje su vrste intermodalnih mehanizama dizajnirane u bilo kojoj reprezentaciji. Ovo su jasni pokazatelji vještina reprezentacijske kompetencije. Stoga svi ovi podatci pokazuju da nije potrebna nova revizija.

Revizije dizajnerskih principa na kraju mikrociklusa 1 i 2

Na temelju evaluacije, izvršena su neka poboljšanja i dorade dizajnerskih principa. Tri su principa revidirana, a jedan je dodan na temelju podataka dobivenih u mikrociklusima 1 i 2 te prijedloga stručnjaka i učitelja sudionika. Dodana je točka za samoprocjenu kako bi se poboljšale vještine evaluacije reprezentacijske kompetencije kod učitelja. Nadalje, istraživač je odlučio postupno povećavati razinu reprezentacijskih izazova, smanjivati razinu podrške te obogatiti dostupne resurse u svakoj aktivnosti kako bi se poboljšale učiteljske vještine u odabiru i dizajniranju reprezentacija. Ovo je prikazano u tablici s obrazloženjem (Tablica 7).

Tablica 7
Prvi revidirani i dodani principi dizajna i njihova obrazloženja

Početni DP	Revidirani DP	Obrazloženje
Na kraju, učitelj kao epistemološki autoritet treba ocijeniti učeničke proizvode (multimodalne prikaze) prema rubrikama za multimodalnu procjenu.	Vanjske prikaze učenika najprije treba sami evaluirati uzimajući u obzir intermodalne odnose, a zatim ih učitelj treba ocijeniti prema kriterijima multimodalne analize.	Samoprocjena može biti ključni čimbenik za proces kritičkoga uokvirivanja, u kojem učitelji mogu reflektirati na svoj dizajn. Učitelji bi trebali podržati eksplicitnu raspravu o multimodalnim prikazima i pomoći učenicima u evaluaciji korisnosti određenih oblika prikaza.
Dizajneri trebaju susresti reprezentacijske izazove koji potiču njihovo uzročno razumijevanje fenomena.	Dizajneri trebaju se suočiti s sve težim reprezentacijskim izazovima, pri čemu razina potpore koju pružaju učitelji treba proporcionalno opadati s povećanjem težine izazova.	Reprezentacijski izazovi uz smanjenu podršku mogu biti učinkoviti u poboljšanju reprezentacijske kompetencije učitelja jer podatci dobiveni od istraživača pružaju određene naznake o ovom smjeru.
Učitelji bi trebali predstavljati osmišljene multimodalne tekstove usklađivanjem i organiziranjem dostupnih dizajna.	Učitelji bi trebali predstavljati osmišljene multimodalne tekstove u različitim medijima, poput videa i priručnika, kako bi obogatili pedagoško okružje.	Osim videozapisa I povratnih informacija koje daje učitelj, potrebna je i izravna pouka u modelu jer je vrlo teško razumjeti visok stupanj međumodalnih odnosa.

	Dodani DP	
	Dizajneri bi trebali imati slobodu odabrati aplikacije u kojima dizajniraju multimodalne reprezentacije.	Budući da svaki sudionik ima različite vještine u korištenju različitih digitalnih alata prilikom dizajniranja svojih reprezentacija, većina njih predložila je da bi fleksibilnost u odabiru medija mogla biti korisna za proces izgradnje.

Revizije dizajnerskih principa na kraju mikrociklusa 3 i 4

Na temelju nalaza evaluacije mikrociklusa 3 i 4, jedan dizajnerski princip je revidiran, a dodan je i novi. Dodana je tema evaluacije vršnjaka kako bi se unaprijedila reprezentacijska kompetencija sudionika u vještini evaluacije. Omogućena je interakcija među učiteljima s ciljem poboljšanja njihove reprezentacijske kompetencije u odabiru i dizajniranju. Ova unaprjeđenja prikazana su u Tablici 8 s obrazloženjem.

Tablica 8
Drugi put revidirani i dodani principi dizajna

Početni DP	Konačni DP	Obrazloženje
Vanjske reprezentacije učenika prvo bi trebalioni sami i procijeniti, uzimajući u obzir međumodalne odnose, a zatim ih treba procijeniti učitelj prema kriterijima multimodalne analize.	Procjena vanjskih reprezentacija treba se provesti u tri koraka: samoprocjena, procjena vršnjaka i procjena epistemološkoga autoriteta.	Provođenje samoprocjene i procjene vršnjaka ključni je faktor za proces kritičkoga kadriranja i za razumijevanje jesu li sudionici reprezentacijski kompetentni ili nisu.
	Dodani DP	
	Multimodalno okružje za učenje trebalo bi omogućiti određene prilike za interakcije među dizajnerima.	Tako bi učenici mogli međusobno pomagati u prevladavanju problema tijekom takvih interakcija.

Rasprava

U ovom dijelu raspravlja se o nalazima istraživanja i donose se zaključci. Rasprava je vođena o dvije glavne, međusobno povezane teme. Prva se odnosi na rezultate dobivene za razvoj MPOU-a, s obzirom da je istraživanje edukacijskoga dizajna provedeno kroz intervenciju (McKenney i Reeves, 2014). Druga tema razmatra utjecaj modela na kompetencije učitelja darovitih (UDU) u dizajniranju multimodalnih tekstova.

The MPOU

Na kraju mikrociklusa 1 i 2, rezultati su pokazali da su učitelji stekli manju sklonost prema odabiru visoko multimodalnih reprezentacija među dostupnima te prema korištenju različitih modaliteta uzimajući u obzir relevantnost teme i ciljeve u nastavnom procesu. Iako su učitelji bili svjesni intermodalnih odnosa i namjeravali su ih dizajnirati, nastavili su s praksom dizajniranja odnosa niže razine. Ukratko, nalazi u prvim mikrociklusima

pokazali su da su učitelji bili dobri u prepoznavanju i odabiru multimodalnih reprezentacija više razine, ali su se mučili s njihovim samostalnim dizajniranjem.

Na kraju mikrociklusa 1 i 3, nalazi su otkrili da su učitelji napredovali u prepoznavanju, opisivanju i identificiranju intermodalnih odnosa, ali su se suočavali s teškoćama u dizajnu — slično istraživanju Tolpanena i sur. (2016), koji su utvrdili da pouka o multimodalnom pisanju povećava uporabu multimodalnih reprezentacija, ali ne osposobljava učenike za integraciju modaliteta. Na temelju intervjua i prikupljenih podataka, revidirani su principi dizajna modela kako bi se izazovi postupno predstavljali, čime se može unaprijediti reprezentacijska kompetencija (Hubber i Tytler, 2017; Tytler i sur., 2013).

Na temelju rezultata, prethodni princip dizajna revidiran je na sljedeći način:

„Dizajneri se trebaju suočiti s postupno sve zahtjevnijim reprezentacijskim izazovima, dok se razina podrške koju pružaju učitelji treba smanjivati u skladu s povećanjem težine izazova."

Druga točka naglašava da će samoprocjena doprinijeti razvoju reprezentacijske kompetencije. U prvoj iteraciji, s obzirom na to da je učitelj bio epistemološki autoritet, smatralo se da je njegova procjena korisna i dovoljna. Međutim, sudionici i stručnjaci smatrali su da bi samoprocjena mogla biti učinkovita. Pregled literature također je pokazao važnost ovoag aspekta (Andersen i Munksby, 2018; Kohl i Finkelstein, 2005; Tippett, 2016).

Stoga je prethodni princip dizajna revidiran kao:

„Učenici bi trebali provesti samoprocjenu svojih multimodalnih reprezentacija s obzirom na kriterije intermodalnih odnosa i koherentnosti teksta, a potom učitelj treba evaluirati i dati progresivne povratne informacije na reprezentacije učenika."

Još jedan naglasak iz nalaza odnosi se na fleksibilnost u korištenju digitalnih aplikacija koje omogućuju učenicima dizajniranje reprezentacija. Sudionici su istaknuli da bi im ova fleksibilnost omogućila bolje dizajniranje reprezentacija. Primjerice, T1 je naveo:

„Bavim se malo s photoshopom, možemo li dizajnirati pomoću alata koji želimo i poslati ga vama? Možda bismo mogli koristiti različite aplikacije, pa mislim da bi bilo bolje biti fleksibilan u korištenju aplikacija."

Stoga je dodan novi princip dizajna:

„Dizajneri trebaju imati slobodu izbora aplikacija u kojima dizajniraju multimodalne reprezentacije."

Posljednja izmjena odnosi se na potrebu za priručnikom jer eksplicitna pouka putem multimedijalnih alata kao što su video i animacija stvara poteškoće u pristupu dostupnim dizajnima koje je osigurao istraživač. Uzimajući u obzir stilove učenja iskusnih učitelja, DPE bi trebao biti obogaćen dostupnim dizajnima. Prethodni princip dizajna revidiran je na sljedeći način:

„Učitelji bi trebali predstavljati dizajnirane multimodalne reprezentacije u različitim medijima, kao što su video, animacija i priručnici, kako bi obogatili pedagoško okružje."

Na kraju mikrociklusa 3 i 4, analiza vanjskih reprezentacija učitelja i intervjui pokazali su povećanje u dizajniranju visokih razina multimodalnih reprezentacija i smanjenje nižih razina. Međutim, to nije u potpunosti ukazivalo na reprezentacijsku kompetenciju. Stručnjaci su preporučili daljnje testiranje u različitim kontekstima radi potvrde ovoga nalaza. U svjetlu svih ovih mišljenja, provedeno je novo istraživanje literature i utvrđeno je da **će** interakcija povećati broj multimodalnih reprezentacija kojima su izloženi. Na temelju ovoga, revidiran je jedan princip, a dodan je novi princip dizajna. Revidirani princip glasi:

„Evaluacija multimodalnih reprezentacija trebala bi se provoditi kroz tri sljedeća koraka: samoprocjena, procjena vršnjaka i procjena učitelja."

Dodani princip glasi:

„Multimodalno okružje za učenje treba pružiti mogućnosti za interakciju dizajnera tijekom provedbe."

Na kraju mikrociklusa 5, analiza intermodalnih odnosa i koherentnosti teksta, kao i komentari o tekstovima vršnjaka, pokazali su da su učitelji ne samo prepoznavali i analizirali adekvatnost multimodalnih reprezentacija, već su također mogli kritički procijeniti u kojoj mjeri reprezentacija odražava intermodalne odnose i obrasce koherentnosti teksta. Ukratko, ovi parametri pokazali su da se učitelje sada može smatrati reprezentacijski kompetentnima.

Učinci MPOU modela na kompetenciju učitelja u dizajniranju multimodalnih tekstova

Može se reći da uključivanje učenika u bogato multimodalno okružeje vodi poboljšanju reprezentacijskih vještina, posebno u prepoznavanju, odabiru i definiranju. Nalazi se slažu s drugim istraživanjima u literaturi (Keleş, 2016; McDermott i Hand, 2010, 2013; Hubber i sur., 2010; Stieff, 2011; Tippett, 2016). Keleş (2016) je u svojoj studiji naveo da ugrađivanje multimodalnih reprezentacija u nastavne metode pozitivno utječe na učenikovo razumijevanje tih reprezentacija. U drugoj studiji, Stieff (2011) navodi da uključivanje takvih alata u okružje za učenje u okviru kemije poboljšava sposobnost učenika da prepoznaju karakteristike reprezentacija i objasne zašto je određena reprezentacija prikladna za određenu svrhu. Hubber i sur. (2010) također su otkrili da izlaganje učenika okružju bogatom reprezentacijama poboljšava njihovu reprezentacijsku kompetenciju.

Stjecanje reprezentacijske kompetencije kod učitelja može se povezati s raspravama o njihovim multimodalnim dizajnima. Te rasprave obuhvaćaju ključne aspekte poput značajki, strukture, funkcije, integracije i ograničenja reprezentacija, što pozitivno utječe na prepoznavanje, analizu i evaluaciju — temeljne komponente reprezentacijske kompetencije. Slično tome, Daniellson i Selander (2016) su ustanovili da metatekstualne rasprave o multimodalnim reprezentacijama u udžbenicima znanosti poboljšavaju kompetencije učenika. Andersen i Munskby (2018) te Hubber i Tytler (2017) također su izvijestili da otvorene rasprave o modalitetima poboljšavaju sposobnost učenika u

dizajniranju i evaluaciji reprezentacija. Kooperativne rasprave, kao što naglašavaju diSessa (2004) te Kozma i Russell (2005), dodatno podržavaju ove vještine.

Može se reći da je proces povećanja težine zadataka uz istovremeno smanjenje podrške izravno utjecao na vještine odabira, dizajniranja, prevođenja i evaluacije, koje su važne komponente reprezentacijske kompetencije te neizravno utjecao na druge elemente na pozitivan način. Ovaj proces doveo je do poboljšanja reprezentacijske kompetencije jer je učitelje motivirao na uspjeh i omogućio im autonomiju u procesu učenja povećavajući njihovu samostalnost. Waldrip i sur. (2010) ističu da iskustvo samostalnosti i aktivnost u dizajniranju, manipuliranju i revidiranju multimodalnih reprezentacija te suočavanje s reprezentacijskim izazovima igraju ključnu ulogu u poboljšanju reprezentacijskih vještina učenika. Hubber i Tytler (2013) također su ustanovili da pružanje niza reprezentacijskih izazova u nastavi astronomije rezultira kompetentnim korištenjem reprezentacijskoga vokabulara. Drugi razlog za razvoj reprezentacijske kompetencije može biti taj što je model pružio važne prilike za međumodalne transformacije. Ove transformacije odnose se na pretvaranje dostupnih dizajna u nove reprezentacije prema njihovim interesima (Jewitt, 2003; Kress, 2010).

Aktivnosti međumodalne transformacije imaju ključnu ulogu u dizajnerski orijentiranom i multimodalnom poučavanju jer potiču učenike da razmisle o odnosima među modalitetima te o njihovoj strukturi i funkciji. Kao rezultat toga, brojne zadatke dizajna uključene su u sva četiri mikrociklusa. Ove aktivnosti smatraju se ključnima za poboljšanje reprezentacijske kompetencije kroz uranjanje učenika u procese stvaranja značenja (Kress i Selander, 2012; Selander, 2008). Na primjer, Pérez Echeverría i sur. (2010) otkrili su da pružanje čestih prilika za prelazak između modaliteta povećava reprezentacijsku kompetenciju učenika. Slično tome, Waldrip i Prain (2012) sugeriraju da napredak u reprezentacijskoj kompetenciji nastaje kroz napore dizajnera da integriraju reprezentacije. Keles (2016) i Tippett (2011) također ističu da multimodalni pristupi poučavanju, uključujući aktivnosti transformacije, pomažu učenicima u boljem razumijevanju multimodalnih reprezentacija. Gunel i sur. (2016) podupiru ovu tvrdnju pokazujući da netradicionalni zadatci pisanja, u kombinaciji s različitim modalitetima reprezentacije, poboljšavaju reprezentacijsku kompetenciju pružajući učenicima prilike za konverziju između modaliteta. Nadalje, eksplicitno poučavanje međumodalnih odnosa može dodatno ojačati reprezentacijsku kompetenciju. Na primjer, Nam i Cho (2016) proveli su eksperiment u kojem je eksperimentalna skupina, poučena metodom koja naglašava prepoznavanje multimodalnih reprezentacija, nadmašila kontrolnu skupinu u dizajniranju multimodalnih reprezentacija.

Zaključak

Model razvijen u ovom istraživanju može pomoći učiteljima u učinkovitom korištenju multimodalnih reprezentacija, fokusirajući se na međumodalne mehanizme i koherentnost teksta radi poboljšanja nastave i učenja. Pruža solidnu osnovu za unaprjeđenje pedagoških

strategija temeljenih na multimodalnosti. Razumijevanje komplementarnoga odnosa među različitim modalitetima omogućava učiteljima da bolje angažiraju učenike i potiču disciplinarno specifičan diskurs u učionici (Prain i Waldrip, 2006). Dizajniranje nastavnih procesa temeljenih na ovim principima može pridonijeti vrijednim uvidima za eksperimentalna istraživanja u različitim kontekstima (Fernandez-Fontecha i sur., 2019).

Razumijevanjem dinamičke prirode multimodalnih reprezentacija, učitelji mogu donositi informirane odluke o odabiru i dizajniranju materijala koji unaprjeđuju učenje učenika (Jaipal, 2010). Ovo dublje razumijevanje može poboljšati nastavne resurse, praksu u učionici i metode poučavanja (Tippett, 2011). Jasno adresiranje međumodalnih odnosa i koherentnosti teksta smanjuje nesporazume izazvane loše dizajniranim reprezentacijama (Lim, 2018). Programi osposobljavanja koji naglašavaju pedagoški specifične međumodalne odnose mogu pomoći učiteljima u dizajniranju prikladnih pristupa za različite učenike, uključujući darovite ili one kojima je potrebna dodatna podrška.

Ovaj model može informirati buduća istraživanja o učenju s multimodalnim reprezentacijama, integrirajući kogniciju, sustavnu funkcionalnu lingvistiku (SFL) i multimodalnost (Tang i sur., 2014). S obzirom na sve veću uporabu multimodalnih reprezentacija u digitalnim okružjima, ovaj model može biti vodič učiteljima u njihovom planiranju nastave. Buduća istraživanja trebala bi istražiti učinkovitost modela u poboljšanju reprezentacijske kompetencije kod učitelja i učenika u različitim okružjima za učenje te proširiti mjerni alat za reprezentacijsku kompetenciju kako bi uključivao modalitete poput geste i govornoga jezika.

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