Modeling of Infographic Generation Process as a Learning Strategy at the Secondary School Level Based on the Educational Design Research Method [*]

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Abstract

The study aimed to model an infographic design process for the use of infographics as a learning strategy at the secondary school level. A progressive model was suggested in line with a hypothetical perspective regarding the infographic generation process in order to enable learners to resolve and visualize complex information. Using educational design research methodology, the research took place over three meso cycles each comprised of micro cycles: the first two meso cycles included the micro-cycles of analysis and exploration, design and construction and evaluation and reflection and the third meso cycle the evaluation and reflection micro cycle. The study was conducted in collaboration with Information Technology, Science and Technology and Visual Arts teachers and with the participation of 18 7th grade students in the first meso cycle and 19 7th-grade students in the second meso cycle. The infographic design process and the reached infographic design levels were evaluated using the infographic design rubric, reflection forms and focus group interview. Based on the evaluation results obtained at the end of the first two meso cycles, the infographic design process was redesigned and developed. The infographic design process was designed to include the steps of content acquisition, infographic design information, content preparation, content generation, visual design generation, draft generation and digital design in the first meso cycle. In accordance with evaluations, the second meso cycle preserved these steps and implemented a spiral structure to replace the progressive structure of the first meso cycle. Sub-stages were added to meet the determined needs to the infographic design process, training activities were increased and a greater length of time was given for the digital design step. In accordance with the reflection obtained

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throughout the process, laboratory computers used in the design process in the first cycle were replaced with the students' own tablets in the second. The infographic design levels and reflections reached in the second meso cycle indicated that the arrangements made in the infographic design process developed the process. At the end of the comprehensive evaluation undertaken in the third meso cycle, a conclusion was reached that the collaboration between different fields, infographic design experience and the use of learners' own instruments was significant. This study can be distinguished from other relevant studies as it presents a comprehensive process model in accordance with the educational design research method which contains applications within itself regarding the implementation of infographic design strategy in the learning process.

Introduction

Learners in the 21st century first encounter or even own digital instruments at a very young age and are immersed in an intensive information environment in or outside of the school setting. In order for learners to meet the social and professional needs of today's world, they must obtain a proficiency with technological instruments and in understanding and recalling information and be able to effectively use high level thinking skills, access information and make sense of, structure, design and spread that information (P21 Partnership for 21st Century Skills, 2009). Learning environments on the other hand must be enriched with methods and strategies that enable learners to reach these aims. Visualization is one such effective strategy for coping with situations that are rich in data and information (Keller & Tergan, 2005) and enabling learners to interact with the content (Stokes, 2002).

These visuals can assist students in an age in which the establishment of fast and global communication has become a necessity (Metros, 2008). The more recent pictorial turn has given visuals greater critical value in communication and meaning making (Felten, 2008). Learners need to develop visual communication skills and literacy to interpret visual messages and produce effective visual messages (Sims, O'Leary, Cook, & Butland, 2002). Simply living in a world of visual stimuli does not mean that students can earn these skills naturally (Felten, 2008), bringing the question of how these skills can be improved to the forefront (Mohler, 2000; Eilam, 2012).

Visual literacy refers to the ability to correctly interpret and formulate visual messages (Brill, Kim, & Branch, 2007). Visual reading and decoding strategies aiming to make sense of visuals and the provision of coding strategies which aim to form a meaning through the design of visuals have been suggested as two methods to obtain visual literacy skills (Heinich, Molenda, Russell, & Smaldino, 1999). Both strategies focus on the concept of meaning.

The meaningful learning approach focuses on meaning making by the learner in the learning process and centers information as the aim of understanding (Biggs, 2003). Understanding is a higher-level form in comparison to the simple recall of information (White & Gunstone, 2014). Learners experience the greatest difficulties when interpreting complex information, transferring their knowledge and self-regulation (Chen & McGrath, 2005). Visualization consists of internal (mental images) and external (picture, graphic and animations) representations and can be an effective strategy in the structuring of complex knowledge (Keller & Tergan, 2005). The learner must use deep cognitive and self-regulating strategies in the learning process, resulting in meaningful learning and conceptual explanation (Chin & Brown, 2000). Visualization is an effective strategy as it enables the conversion of the more intensive and complicated conceptual structure from working memory to external visuals and their representation (Ware, 2005).

Visualization can mean either the transfer of a simple opinion or concept into a visual by using pen and paper or the entire structuring process including the search, definition and presentation of a complicated conceptual structure (Foster, 2008). The visualization of knowledge means its adoption into a form that becomes more accessible and manageable (Eppler & Burkhard, 2004). By making their concept more visible, the learner is able to transform their idea or knowledge into information, consider the generated meaning and re-organize their thinking process in a detailed manner (Chen & McGrath, 2005).

In the knowledge visualization, information should be designed in such a way that enables communication between the sender and receiver (Eppler & Burkhard, 2004). In this context, information methods can include sketches, diagrams, pictures, maps, objects, interactive visualization and stories. Marzano, Gaddy, and Dean (2000) examined five principal methods of non-verbal representations, including graphic organizers, pictures and pictograms, mental images, concrete representations and kinesthetic activities and concluded that graphic organizers were more common and suitable for the teaching-learning process.

The generative learning theory proposes that meaningful learning takes place in the discovery of the relationships between the complex pieces of information and between the student's prior knowledge of these pieces and suggests strategies of varying degrees of difficulty from forming titles to establishing analogies (Wittrock, 1992). These strategies, text and visuals help to focus the resolution of the formed content via the creation of relationships. Depending on the complexity of the learning situation, the strategies can be used together. It is also recommended that studies using more than one strategy together are necessary (Grabowski, 2004) According to this need, as an effective way of information visualization, the infographic design process can be handled as an integrative strategy which enables the use of both various visualization types and generative learning strategies.

Infographic Design

Infographics enable the communication of complex information (Albers, 2015) and present information in a fast and clear manner through visualization (Smiciklas, 2012). While it aims to relay the message in an accessible and easily understandable way, the focus remains the most correct presentation of information (O'Grady & O'Grady, 2008). Characterized as the most effective meeting point of verbal and non-verbal systems (Krauss, 2012), infographics enable the visualization of the big picture of complex content (Lamb & Johnson, 2014). Infographics differ from other visualization methods owing to their ability to display the relationships of complicated information and provide a general framework regarding the conversion of content into a holistic visual via complimentary text and graphics (Albers, 2015). Esthetics and visual design remain important for infographic design as does the right selection of verbal wording (Hankey, Longley, Tuszynski, & Ganesh, 2013). The communication of complex relationships forms the foundation for the effective communication of complicated information (Albers, 2014).

There are different approaches for determining the appropriate infographic type for its purposes. Albers (2015) categorized infographic types as bulleted list, spontaneous display regarding graphical needs or straight information and information flow infographics whilst Dyjur and Li (2015) defined nine different types including comparison, flow diagram, time bands, process, visual-based, data, story-like, metaphor and mixed. Hagen and Golombisky (2010) defined the components and parts of infographics and stated that infographics are designed by bringing these together.

As the concept of visual literacy becomes more prominent, discussion over how infographic design in the educational context can be embraced has gained importance (Farrell, 2013). Infographic design requires a process that the learner interprets and generates the information in an active way by

its very nature. So, it is thought that "Generative Learning Theory (Wittrock, 1992)" provide basis to infographic desing process with its its theoretical point of view that suggests active interpretation of learners and learning activities. On the other hand, Generative Learning Theory suggests designing of learning environments by combining different learning activities. In addition, verbal and non-verbal stages which infographic design necessitates match up with the Generative Learning activities in the scope of this theory.

Generative Learning Theory

According to generative learning theory, learning takes place with the generation of meaningful relationships between newly encountered information and the previously existing experience and information in long-term memory, and in the active meaning making (Wittrock, 1992). Two types of generative learning activities are defined: those that generate organizational and those that generate integrative relationships (Wittrock, 1990). Organizational activities are oriented at generating relationships between the different components of the content. Suggested strategies include finding titles, test formulation, determination of aims, summary, drawing graphics, table formulation and extraction of main themes. Integrative activities are those that enable the generation of relationships between external stimuli and memory components as prior knowledge and experiences. Demonstrations, metaphors, analogies, examples, pictures, applications, interpretations and paraphrases and inferences are suggested as generative activities that enable integration.

In order to characterize an activity as generative, it must include meaning-making (Grabowski, 2004). The learner must analyze the presented information, generate relations and then formulate meaning within this context. The important thing is what the learner thinks following the information given or that reached as an answer and how they combine it with their information (Wittrock, 1990). Generative learning does not define a dominant role of the learner, teacher or instruction and is instead based on the assumption that these three have a partnership throughout the process (Lee, Lim, & Grabowski, 2008). Learners participate in the learning situations and generate relationships between new and previous information, re-organize the information encountered in this regard and conceptualize, elaborate and associate with it (Wittrock, 1992).

Taking into consideration studies conducted on generative learning strategies, Grabowski (2004) classified generative learning activities into simple coding, complex coding and integration strategies. In simple coding, the learner tries to analyze the content by underlining, note-taking or adjunct or inserted questions. In complex coding learner tries to generate a relationship on the context by using organizational strategies and manipulation of objects. Creation of a hierarchy between content components, matching components, constructing an introduction to the content and studying the meanings of sentences have been suggested as organizational studies. In order to establish a relationship regarding integration, strategies such as imaging the content, elaboration studies on content or finding analogies about the content have been suggested.

Depending on the learning situation, the order of utilizing the strategies is important. The degree of difficulty of the established relationship also help determine which strategies can necessitate a more complex cognitive process for realization. The ordering of strategies belonging to activities is supportive in preparing learners for more complicated cognitive processes (Grabowski, 2004).

Infographic Design at the Secondary School Level

Kos and Sims (2014) and Davidson (2014) studied the infographic design process as a learning strategy at the secondary school level. Both studies presented a suggested infographic design process.

Kos and Sims (2014) carried out a five-week study in which students were asked to prepare an infographic about a career selected from a STEM career list and make a presentation of the infographics. The infographic structure was presented in a familiar 5-paragraph essay format. The implementation process consisted of the following steps, introduction, research, organization and flow of information, design, study, peer evaluation and study, last study and presentation stages. Good and bad infographic examples were given and the subject list was shared with the students. In the research stage, students carried out their research about their chosen subject field and were asked to form drafts following the 5-paragraph essay structure in the organization and information flow stage. Infographics were to include sections corresponding to the five parts of an essay.

The design stage was examined in two separate sub-stages: text and colors and graphics and pictures. In the text and colors stage, the foundations of design were developed and online instruments were examined. By choosing their instruments and templates, students were able to transition to design in the digital setting based on their drafts. In the graphics and pictures stage, the composition of good visuals and graphics was taught and students were asked to visualize their own infographics. In the following three stages, students worked on their infographics, completed their studies in line with the peer evaluation and feedback provided by the teachers and presented their projects, respectively. Infographics were evaluated using two separate rubrics developed by the researcher: the content and information rubric and the design and esthetic rubric. The content and information rubric consisted of the dimensions of fact, graphics, pictures and resources and the design and esthetic rubric the dimensions of readability, emphasis, simplicity and consistency.

Kos and Sims (2014) reported flaws due to conditions of the computer setting and loss of student username and password information of online tool accounts. In addition to technical problems, the authors stressed that the infographic design processes were negatively affected by insufficient image processing tools and the students' tendency to maintain essay writing habits when adding texts to their infographics. On the other hand, the authors stated that the image processing tools provided templates; supported the infographic generation process of students with different levels of creativity and technical skills; that infographics were a more effective method in comparison to a 5-paragraph essay when it comes to the visualization of data and findings; and that they supported the participation of students whose first language was different from that of instruction in the lesson. The researchers reported that students found infographic generation to be more entertaining than essay writing, that they were willing to present the generated infographics and wanted do the process again in the future.

Davidson (2014) stressed that effective infographics had eye-catching titles, simple readable text, clear, suitable and original visuals and consistent text, diagrams and colors. The infographic creation process evaluates infographic examples via questions and discusses how the infographics could be more effective. Students were asked to find five infographics developed around a certain subject, choose the best one and present in class why they chose that particular infographic. Subsequently, good infographic standards were discussed and students evaluated the infographics presented in the following stages in accordance with these standards. Students were able to design infographics using whichever instrument they preferred and were directed to continue to re-organize their designs until they achieved the best conformity between information and design. Following the design stage, students examined each other's infographics in accordance with given criteria that focus on the detreat of how the content is reflected, the visual quality of the infographic, the organization of information and the effective presentation.

In a study carried out in a secondary school science class, Davidson (2014) reported that students learned to filter information by accessing reliable resources, finding appropriate visuals and

developing them, organizing data, placing findings obtained at the end of laboratory observations and researching and updating infographics until they meet the criteria determined by the class. In addition to the content received regarding the actual science class, students developed their media and digital literacy and managed to prepare their infographics in a shorter time frame than with a published classical poster.

Aim of the Study

The aim of this study was to model the infographic design process for the generation of infographics as a learning strategy. A hypothetical perspective and step-by-step model was developed as an effective visualization method for the infographic generation process to be followed by learners at the secondary school level to resolve and visualize complex information. Creation of a learning process is aimed in this study that the learners can improve their abilities like higher order thinking, critical thinking, problem solving, information literacy and visual literacy by the help of infographic design strategy which entails a multi-dimensional learning process.

Research Questions and Sub- Questions

How should the infographic generation process for students at the secondary school level be modelled as a learning strategy?

- What is the level of students' infographic designs with respect to the content resolution and visual design resolution components?
- What are the opinions of students and teachers regarding the infographic design process in the learning and teaching process?

Method

The study is based on the generic model of educational design research (McKenney & Reeves, 2012). Educational design research method aims to develop a product, process, program or policy oriented at both the hypothetical and application perspective in accordance with a flexible and repetitive approach in collaboration with stakeholders in real life situations until a certain level of saturation is reached.

In educational design research (McKenney & Reeves, 2012), it is suggested that meso cycles be established by combining the micro cycles of analysis and exploration, design and construction, evaluation and reflection until the optimal results are determined. Meso cycles are comprised of micro cycles and come together to form macro cycles. The goal of analysis and exploration micro cycles is to define the problem, establish collaboration with the implementers, review the literature, define aims, identify the capabilities of the context in which the application will take place and establish the precursor design suggestion.

In the design and development micro cycle, methods and techniques are designed and the hypothetical and implementation oriented approaches on which the design is based and the implementation method oriented at hypothetical testing and their applications and reasons are explained. Finally, the evaluation and reflection micro cycle includes the examination of the validity, applicability and effectiveness of the designed process in accordance with the aim and the evaluation of the design in line with the data and subjective reactions regarding the process in order to settle the hypothetical perspective, along with the provision of results with the purpose of contributing to the implementation and hypothetical perspective regarding the subsequent meso cycle.

Study Group and Role of the Researcher

The study was performed at a private secondary school and included eighteen 7th-grade students (9 girls, 12 boys) in the 2013-14 spring period in the first meso cycle and nineteen 7th-grade students (11 girls, 8 boys) in the second. Application was performed with different student groups in the same grade who have meet with the term of infographics for the first time and never experienced infographic design in order to prove the whole process of model. Students had been studied information technology courses from 1st grade and joined related learning activities in the tablet classes. The implementation process was conducted in accordance with the meaningful partnership (McKenney & Reeves, 2012, p. 17) established on the basis of "collaborative learning agreement" (Wagner, 1997) among teachers in the fields of Information Technology, Science and Technology, and Visual Arts. Technology integration and technology literacy ability of participant teachers had been updated annually by inservice education program.

Data Collection Instruments

Infographic Design Rubric (IDR)

The infographics were evaluated using the Infographic Design Rubric (IDR) (Nuhoğlu Kibar & Akkoyunlu, 2017). The IDR consists of two dimensions (content generation and visual design generation) and 32 criteria and provides explanations on 4 performance levels (Table 1). The content generation dimension includes the organization of information and its quality whilst the visual design generation dimension includes the big picture along with sub continents. The elements are classified into two groups within themselves including font and colors and visuals.

Table 1. Dimensions of the Infographic Design Rubric

Content Generation	Visual Design Generation	
Main Heading	**Big Picture**	**Components/Text**
Sub-headings	Visual Hierarchy	Font type
Organization of Information	Redirection	Font Color
Groupings	Rhythm	Font size
Systematics	Emphasis	Font case
Consistency	Consistency	Line length
Quality of Information	Balance	Line spacing
Essential Information	Integrity	Justification
Key Concepts	**Components/Colors and Visuals**	
Descriptions	Color harmony	Color Effect on Visibility of Information
Exemplification	Background color	Color effect on Redirection
Outcome	Tags of visuals	Visual reflection of Information
Identity	Reality level of visuals	

Reflection Forms

Reflection forms were prepared based on a SWOT analysis to determine the opinions of students and teachers of the process. The student form consisted of sections with the titles "Things I could do well when designing infographics", "Things I can't do well when designing infographics", "Things that make it easy for me to design infographic" and "Things that make it difficult to design infographics". The teacher form was prepared to solicit teacher thoughts on student feedback and experience. In addition, teachers were also asked about their suggestions for improvement in the process and general opinions about the implementation.

Teacher Focus Group Interview Forms

At the end of the second meso cycle, a focus group interview structured into the stages of introduction, introductory questions, transition questions, key questions, research questions and closing questions was carried out with the participating teachers (Çokluk, Yılmaz, & Oğuz, 2011). The introduction summarized the infographic design processes and participants were asked to share their general positive/negative general impressions about the process in the introductory question stage and their positive and negative opinions in a detailed manner in the transition questions stage. In the key questions stage, teachers were asked about the things that could be done to improve the process and about how the process benefited the students in the research questions stage. The closing stage focused on the teachers' intentions to use the infographic generation strategy in future learning processes.

Data Analysis

Student and teacher reflections were obtained at the end of the 1st and 2nd meso cycles and the focus group discussion was held with teachers within the 3rd meso cycle. A 37-minute 6,680-word recording was made of the focus group interview. The written reflections and focus group interview were broken into meaningful parts through coding and were analyzed (Miles & Huberman, 1994). Reflections were coded via the inductive coding technique (Strauss & Corbin, 1990). Control coding (Miles & Huberman, 1994) was carried out in approximately 25% of data and the researchers compared coding together subsequent to carrying out coding separately. The reliability among coders was 67.25% at the end of the first coding transaction and 87.50% in the control coding. The difference between the first and control coding was thought to stem from the lack of complete awareness of the extent of codes presented in the beginning list by the coder.

Research Model

The research was carried out in three meso cycles in accordance with the educational design research method. The first two meso cycles each included the "analysis and exploration", "design and construction" and "evaluation and reflection" micro cycles and the third meso cycle included the "evaluation and reflection" micro cycle (Fig. 1). The analysis and exploration micro cycles analyzed and explored factors that could impact the research process, the design and development micro cycles constructed the implementation process and the evaluation and reflection cycles analyzed data obtained in the research and made inferences regarding process improvement for use in subsequent cycles. The educational research method is shaped by consecutive cycles and consists of sub studies that begin with analysis and end with evaluation that feeds the next meso cycle. Part of the findings reached in the first meso cycle was presented as a paper by the researchers to obtain feedback and gain a multi-dimensional perspective on the international scale for improvement in the second meso cycle. The first meso cycle is examined here in detail with its wider collected data to describe and highlight the relationship and changes between the cycles.
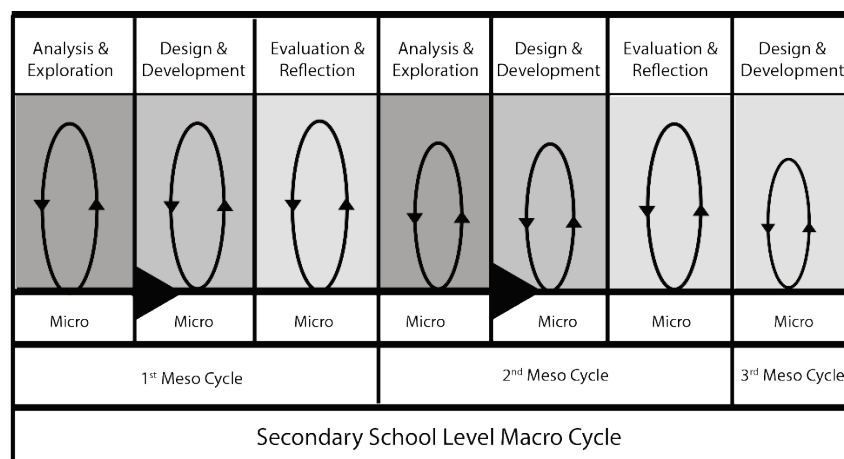

Figure 1. The Study's Micro, Meso and Macro Cycles

The First Meso Cycle
Analysis and Exploration

As the first analysis and exploration micro cycle, the first meso cycle analysis and exploration micro cycle consisted of detailed analysis and examination of the research context. Two teacher seminars and a meeting of the secondary school's R&D division was carried out in order to establish a meaningful collaboration between the implementer and the researcher, necessary in the educational design research, and to determine the conditions of the research's context.

The infographic notion was examined in the first seminar and the suggested research and implementation model was presented. Science and Technology lessons were determined to be appropriate for this implementation and Information Technology and Visual Arts teachers were selected to participate. The second teacher seminar was part of the implementation process and was conducted prior to implementation with the teachers who were to participate in the study over the course of two days in four sessions. Visualization methods were examined with emphasis on the infographic concept and the infographic examples were examined from the perspective of design elements and principles. The infographic design process was examined in detail, infographic drafts were generated by following the infographic design process steps and teacher suggestions were obtained.

In a meeting attended by all participating teachers and the school R&D division specialists, it was decided that the implementation should be made at the 7th grade level taking into consideration students' knowledge of and skills with digital instruments. The topic of Simple Machines was selected as the infographic learning outcome. It was emphasized that the implementation should be carried out without distracting from the natural learning context based on a feature of educational design research. Dates for the classroom implementation were determined by the R&D division and the teachers that would play an active role in the process and a collaborative network was established with the teachers.

Design and Development

The infographic design process was based on the components of content generation, visual design generation and digital design and was carried out over 7 weeks during weekly 1-2 sessions consisting of the principal stages of content acquisition, infographic design information, content preparation, content generation, visual design generation, draft formulation and digital design (Fig. 2).
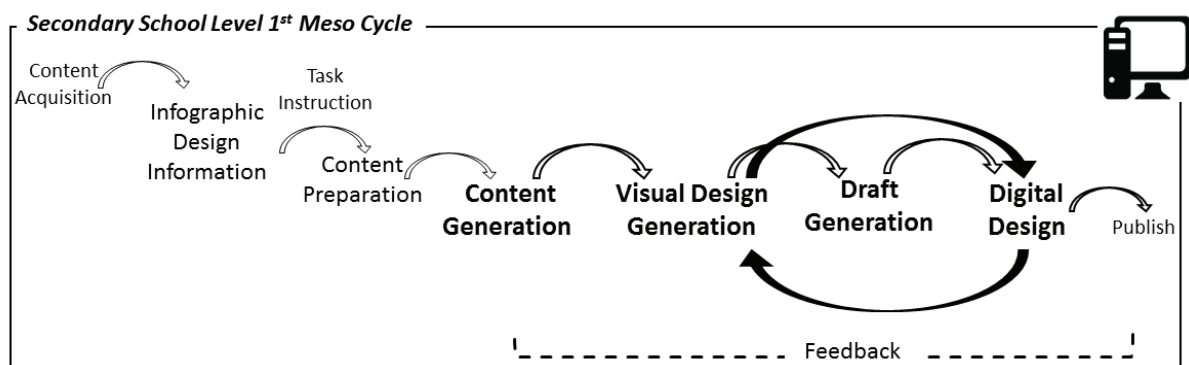

Figure 2. Infographic Design Stages in the First Meso Cycle

The chosen subject was examined by the Science and Technology Teacher in the content acquisition stage and students were informed about the infographic design activity to be performed in the next lesson. Following content acquisition stage, the infographic design information stage was implemented by Information Technology teacher. The infographic concept was presented as a dynamic infographic video and the elements and design principles were examined based on infographic examples. The implementation was carried out targeting principles on the infographic worksheets. Following the completion of the infographic design lesson, students were asked to prepare raw content of relevant text and visuals to answer the questions in the directive for the next lesson.

Based on the prepared content, the first 10 steps of the content generation road map (Fig. 3) were completed and the content generation and draft formulation steps were carried out with teachers under the leadership of Information Technology Teacher in collaboration with the Science and Technology Teacher. Immediately following the content generation step, the 5-step draft formulation stage was begun. It was asked that generated content be transferred as a draft to size A3 paper distributed by the teacher. Following the completion of the drafts, feedback was provided by the Science and Technology and Visual Arts teachers. Feedback was attached to the drafts via sticky papers and distributed to students in the subsequent lesson.
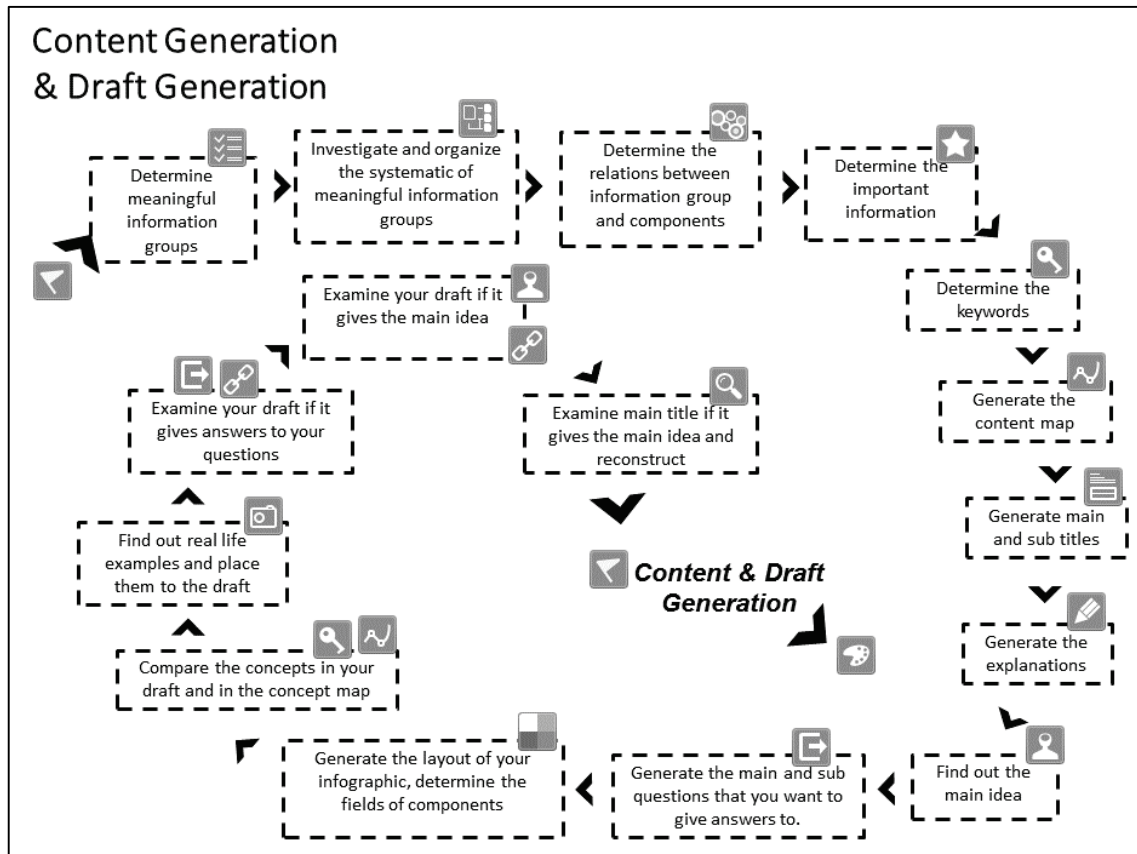

Figure 3. Content Generation and Draft Formulation Road Map

The digital design stage took place in the computer laboratory using MS Office Power Point desktop software under the leadership of the Information Technologies teacher in collaboration with the Visual Arts Teacher. Each student was given access to one computer. The software was chosen as it was previously uploaded on computers in a licensed format and students enjoyed a decent degree of competence with respect to using it. The students carried out the digital design stage by examining their drafts and feedback.

Print-outs of the students' digital designs were made and feedback was provided with sticky papers at the end of the first lesson to allow students to observe the relationship between the computer platform and the real dimensions of their designs. As such, they were provided with a perspective on how designs made on the computer monitor would appear on printed A3 paper.

Evaluation and Reflection

The implementation process and model was evaluated in accordance with the levels of designed infographics in comparison to rubric dimensions and the reflections of students and teachers. Upon examination of the IDR results, it was found that visual design generation dimension ($\bar{X}$= 2.22) was lower than the content generation dimension ($\bar{X}$= 3.33) (Table 2). The levels of measured dimensions reached in content generation were almost wholly above 3. It was observed that concept generation

could be supported a little more through the measures of consistency ($\bar{X}$= 2.89), systematic ($\bar{X}$= 3.17) and descriptions ($\bar{X}$= 3.17). The results indicated that the measures in the color and visuals ($\bar{X}$= 2.60) sub-dimension of the visual design generation dimension need to be emphasized.

Table 2. IDR Results in the First Meso Cycle

	$\bar{X}$	S.S.
Infographic Design	2.60	0.54
Content Generation	3.66	0.60
Main Heading	3.28	0.46
Sub Headings	3.50	0.79
Grouping	3.39	0.85
Systematics	3.17	0.79
Consistency	2.89	1.13
Essential Information	3.22	0.81
Key Concepts	3.72	0.58
Descriptions	3.17	0.86
Outcome	3.44	1.15
Identity	4.00	4.00
Visual Design Generation	2.22	0.54
Big Picture	3.11	0.76
Visual Hierarchy	3.28	0.96
Redirection	3.11	0.76
Rhythm	3.39	0.70
Emphasis	2.72	1.07
Consistency	3.17	0.86
Balance	3.11	0.83
Integrity	3.06	0.94
Components/Text	3.28	0.46
Font type	3.89	0.47
Font color	3.67	0.49
Font size	4.00	0.00
Font Case	3.83	0.71
Line Length	3.94	0.24
Line Spacing	3.94	0.24
Justification	4.00	0.00
Components/Colors and Visuals	2.65	0.84
Color Effect on Visibility of Information	2.72	1.13
Color harmony	2.67	1.19
Color Effect on Redirection	2.67	1.14
Background Color	2.89	1.18
Visual Reflection of Information	2.83	0.92
Reality level of Visuals	3.00	1.09
Tags of Visuals	1.83	1.25
Components	3.28	0.46

Fifty-five percent of students stated in their reflections that they could carry out content generation compatible with the infographic design results while 50% stated that they could create colors and visuals to a good standard (Table 3). 38.88% stated that they could not create colors or visuals well and 33.33% stated that they were not good at creating big picture sub-dimensions. A noteworthy finding was that 50% of students stated that they could work well in the digital setting while 27.7% could not perform well when it came to formulating a detailed daft on paper. Additionally, 77.77% emphasized that working in digital settings made the design processes easy. The importance of feedback was illustrated by the fact that 66.66% of students mentioned that feedback given in the design process made the process easier. Students stated that time constraints and visual design generation dimension made the infographic design processes more difficult.

Table 3. The Theme, Code, Frequency and Percentages of Reflections by Students Regarding the Process in the First Meso Cycle

Theme	Code	Freq.	%
Things I can do well when designing an Infographic	Content Generation	10	55.55
	Visual Design Generation– Big Picture	3	16.66
	Visual Design Generation – Components/Text	6	33.33
	Visual Design Generation – Components/Colors and Visuals	9	50.00
	Working in the Digital Setting	9	50.00
Things I can't do well when designing an Infographic	Content Generation	4	22.22
	Visual Design Generation– Big Picture	6	33.33
	Visual Design Generation – Components/Text	5	27.77
	Visual Design Generation – Components/colors and Visuals	7	38.88
	Forming a Detailed Draft on Paper	5	27.77
Things that make it easy for me to design an Infographic	Feedback	12	66.66
	Working in the Digital Setting	14	77.77
	Internet	8	44.44
	Course on What an Infographic is and How it is Designed	7	38.88
	Science Lesson Book/Notebook	4	22.22
Things that make it difficult for me to design an infographic	Lack of Sufficient Time	12	66.66
	Visual Design Generation	11	61.11
	Technical Faults	3	16.66
	Forming a Detailed Draft on Paper	3	16.66
	Number of Students Answering the Questions	18	100

Teachers stated that students had no difficulty in content generation and transferring the content to the draft and that they were comfortable working in the digital setting, which was rather similar to the opinions expressed by students (Table 4). They stated that students experienced difficulties when forming a detailed draft on paper or forming the big picture and that they were not as comfortable in determining colors and visuals as they were in content generation. The Science and Technology teacher reported that students had difficulty in forming the heading component which was directly related with the effectiveness of the infographic. The Information Technology teacher reported a general issue in saving and transferring the digital files of the project which significantly affected time management.

Similar to student opinion, teachers reported that the instructions given at the beginning of the process and the feedback provided in the process made the design of the infographic easier and emphasized the importance of collaboration between fields. However, they stated that the infographic design process consumes a lot of time and that the inability to set out sufficient time in order to work on infographic designs in schools represents a problem. They stressed that the preparation of a detailed draft on an A3-sized paper takes a long time and significantly extended the process.

Table 4. The Themes and Codes on the Opinions of Teachers Regarding the Process in the First Meso Cycle

	Science and Technology (T_ST)	Visual Arts (T_VA)	Information Technologies (T_IT)
Things students could do with no difficulty whilst designing an Infographic	Content generation and transferring to draft		Transferring content to design
	Working in the digital setting		
Things students had difficulty with whilst designing an Infographic	Forming a detailed draft on paper		
	Visual design generation (big picture)		
	Visual design generation (colors and visuals)	Visual design generation (colors and visuals)	Visual design generation (visuals)
	Finding a Heading	Visual design generation for detailed draft on paper (text)	Saving and transferring the digital files of the project
Factors that make designing easy	Working in the digital setting		
	Course on what is an Infographic and how is it designed		
	Feedback		
	Cooperation between fields		
Factors that make designing difficult	The dispersion of study over time and lack of time		
	Forming a detailed draft on paper		

Teachers emphasized the positive impact of the content generation process on learning the subject and reported that students were able to create information visualization. The content generation stage in particular encouraged the student to examine in detail the subject embraced in the Science and Technology lesson, determine their gaps through feedback and obtain a better grasp of the subject.

> *"Despite having gone over the subject, it hadn't yet consolidated when the infographic design process began. (…) As such, there were drawbacks and insufficiencies in the raw content they brought for the content generation stage. I am of the opinion that examination, provision of feedback and guidance in the content generation stage is a correct and positive thing to do. (…) I could comfortably say that they began to consolidate the subject matter which they never really fully understood in the first place." (T_ST)*

> *"I think that they managed to understand the subject much better when undertaking research for content generation." (T_VA)*

> *"The detailed realization of the content generation and draft formulation enabled students to work more on the content while they had no difficulties at the design stage with respect to content." (T_IT)*

Teachers also reported that students were able to visualize a complex and difficult subject taught in class via the application using the digital setting:

> *"Students realized how a complex subject could be understood more easily. (...) They learned how to find and use the best visuals to fits the theme. (...) They liked studying in the digital environment very much.." (T_VA)*

Students gained experience in formulating visuals at the introductory level in addition to using ready-made visuals:

> *"Very few of the students attempted to draw the visuals by themselves without the provision of feedback instead of using ready-made visuals. For instance, a student that tried to draw the pully of the basic machines after seeing its basic components caught my attention" (T_IT)*

Teachers drew attention to the timing issue and suggested possible amendments to the time-intensive draft formulation stage and the last digital design stage during which time pressure is felt the most. Teachers stated that the time set for the implementation was short and that the time spared for this implementation in the schools should be extended in accordance with the planning:

> *"I believe the process will be faster and more enjoyable if it is planned better and the conditions can be provided to enable them to carry out all studies in the schools. "(T_ST)*

> *"It will be advantageous for the digital design stage to be lengthier to ensure that it will reach every student." (T_VA)*

> *"I could say that the dispersion of the design business over time, the unaccustomedness of students to long haul digital projects and time insufficiency made the process more difficult." (T_IT)*

On the other hand, it was mentioned that issues were experienced in saving the files while working in the digital setting along with transferring them to a different instrument and this hindered the process:

> *"The issue students had the most difficulty with was accessing the files on which they worked in the weeks in which they made designs in the digital setting. This can stem from the fact that they have limited experience in producing long-term digital projects. Very few of them use memory sticks, as such the transfer of files to different study settings (home, from home to school) represented an important problem." (T_IT)*

It was stated that the drafts formulated on paper underwent changes when they were passed on to the digital setting and making the design in the digital setting helped speed up and support the process:

> *"It was observed that the sketches on paper were draft drawings, gave ideas to students in the design process and designs in the digital setting could be more different. The reason why sketches were not adhered to is that it was supported by ready-made templates and images in the digital setting. The student couldn't transfer everything they thought about at the draft stage. However, in their designs from the digital setting they evaluated their opinions in a different process by combining them with images and icons. (…) The students resolved the difficulties encountered at the sketching stage in a faster manner in the digital setting." (T_VA)*

> *"I could say that while it was difficult to make changes working on paper, having the chance to arrange stuff in the digital setting made the process easier." (T_IT)*

The teachers suggested that the time-consuming multi-step draft formulation stage be arranged in a way that would help them use time more productively and produce drafts more quickly:

"First of all, students should be given the logic of sketches and draft design. (…) A student that perceives draft design will move faster in the process of preparing their own draft design and will learn to carry this onto the digital setting." (T_VA)

"If the draft on paper was not formed in detail and we could have spared a greater amount of times for the digital design or kept the scope of the learning outcome narrower against the possibility of experiencing time constraints, higher quality designs could have been produced. On the other hand, the preparation of a detailed draft on paper guided the students to produce the same draft unfortunately, drafts could have been prepared that contained a lesser amount of detail." (T_IT)

It was suggested that students use their own tablets in the design process in order to prevent the issue of file transfer and saving and speed up the design process:

"It could be appropriate to design using different tablet applications that would suit students' ages. (...) The process could be planned with the opinion that working with tablet could reduce the loss of time and speed." (T_VA)

"I don't think there was an issue in the presentation of the lesson on what is an infographic and how it is designed. It could be considered that changes can be made in the stage of preparation of raw content at home or how this process could be made more enjoyable for the student. (…) They really take great pleasure in using tablets. We could make the process such that it is entirely made with tablets." (T_ST)

In addition to the outlined suggestions above, the teachers suggested that the additional activity on infographic design in the learning-teaching process can be integrated into the lesson with groups that know infographic design and applied as such:

"I believe that with a well and rightly planned process and the right guidance, a study that will be made on a few subjects with groups that know infographic really well will be very beneficial. If they can successfully manage to integrate it into the operation of the lesson with a good planning, rather than an extra study, it can be very beneficial." (T_ST)

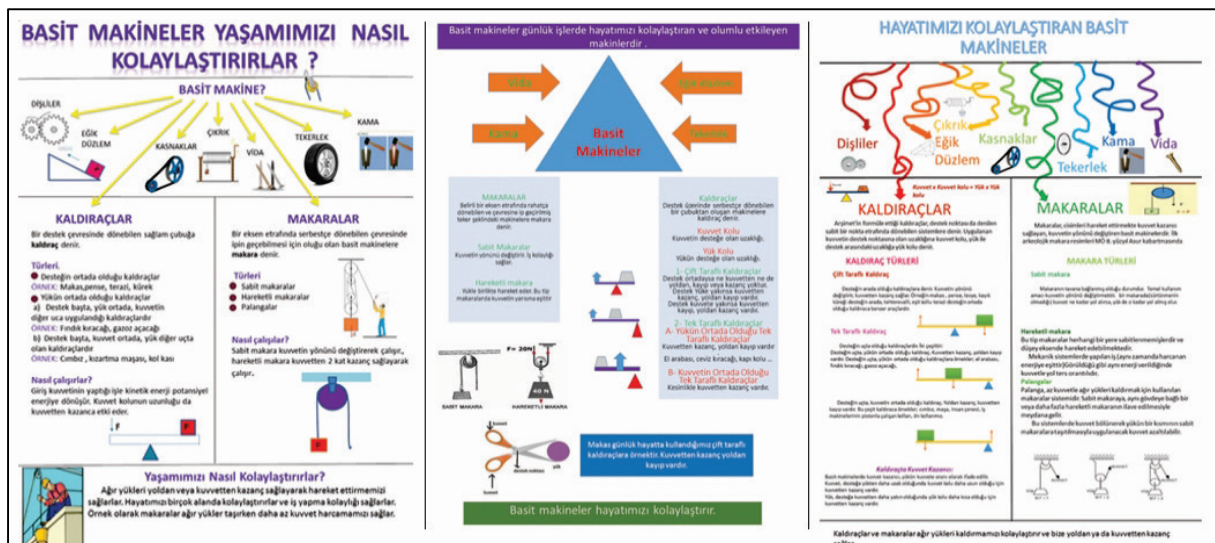Figure 4. contains examples of infographics designed in the first meso cycle.

Figure 4. Examples of Infographics Designed by Students in the First Meso Cycle

The Second Meso Cycle

Analysis and Exploration

Based on the points from the rubric received by students for their infographic designs in the first meso cycle and the findings from the teachers and students, it was concluded that the visual design generation needed improvement and the issue of time addressed. In addition to the fact that infographic design requires an intensive and lengthy investment of time, it must be noted that the design process is even further extended when students are new to the concept of infographics. When the intensity of the instruction program is taken into consideration, the amount of time, lesson type and physical resources the administration can put aside for the infographic implementation is limited. The second implementation improved the infographic design points as much as possible from the perspective of visual design and time management and could be completed over the course of 3 weeks with 2 hours spent per week.

The visual design generation dimension begins with the formulation of draft as an idea and becomes more visible at the digital design stage. It is easier to make information more visible in a textual form as visual design generation remains more difficult at this stage for inexperienced students. For these reasons, shifting the emphasis from content to digital design was seen as a solution given the limited time frame provided. It was thought that the important stages of content generation and draft formulation could be combined and the sub-steps reduced in order to reflect them on the process design in the second cycle.

An additional factor that slows the process down is the transfer of files from the laboratory to the home or from one computer to another and the subsequent file loss. Thus, a structure was established in line with teacher suggestions to enable students to participate in the process. In accordance with the Bring Your Own Device (BYOD) method (Alberta Education, 2012; Rogers, 2016), it was aimed that the students would be able to work with individualized instruments in a manner independent of time and location. The implemented BYOD model refers to the "planned, controlled, and one that includes the general school premises" (Attewell, 2015) and the use of instruments determined by school administration. The students are able to use their devices throughout the lesson with the permission of the teacher and use them whenever they like outside of the lesson. The aim for the teachers is to provide a more collaborative, proactive and interrogative learning environment for students through the use of the devices.

Design and Development

In accordance with the analysis and exploration carried out based on findings of the first meso cycle, the device used in the infographic design process was changed and students were allowed to use their own tablets. As such, the limitation of time, location and device was eliminated. Taking into consideration the properties of the devices, the scope of the learning outcome that will develop the infographic was narrowed and attention was placed on the character of visualization in the content to formulate them in the tablet setting. The learning outcome was selected as Chemical Bonds from the Structure of Matter and Properties unit.

The sequential structure of the content preparation, content generation, draft formulation and digital designing stages in the first meso cycle was re-arranged in a helical structure. The raw content preparation stage was omitted. The draft generation stage of the instruction on infographics and infographic generation was updated and activities directed at the formation of fast drafts on A4 size paper instead of detailed draft generation were planned. Content generation was presented to students, having combined the transaction steps and simplified them.

After the learning outcome was presented in the Science and Technology lesson, the process continued with a presentation and activities focusing on the questions of what is an infographic design and how is it defined (Fig. 5). Activities that drew attention to the criteria of the big picture and the visual design generation sub-dimensions of colors and visuals were performed within the course on information design. While the infographic design information lesson was conducted by the Information

Technology teacher with the participation of the Science and Technology teacher in the first meso cycle, in the second implementation the Science and Technology teacher contributed to the end of the draft generation stage to provide feedback with respect to the content of the digital design stage and the Visual Design teacher contributed to the stages focusing on visual design generation.
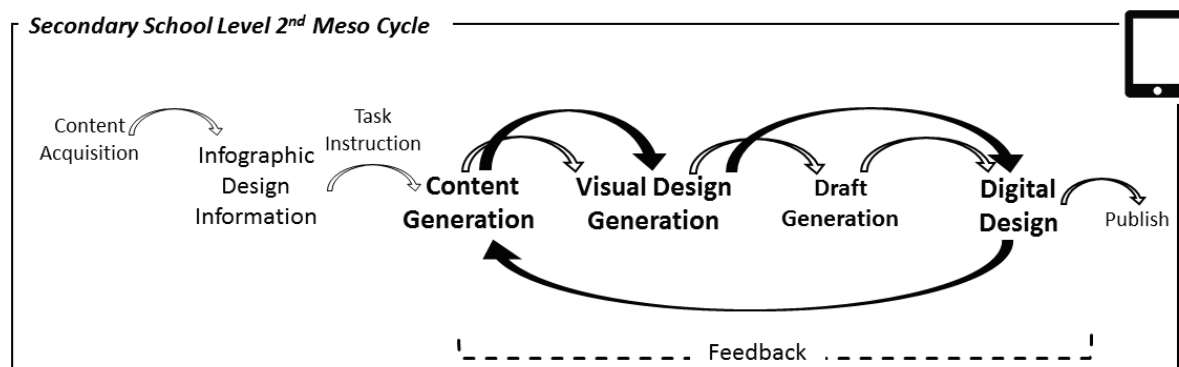

Figure 5. Infographic Design Stages in the Second Meso Cycle

The content generation and draft generation stages were carried out immediately following the instructions provided. The students formed concept maps on their A4 sized drafts, formed the headings and sub-headings and decided how they would be placing the content in accordance with the instruction (Fig. 6). At the end of draft formulation stage and during the digital design stage, rapid feedback was given by the Science and Technology teacher to the lesson.
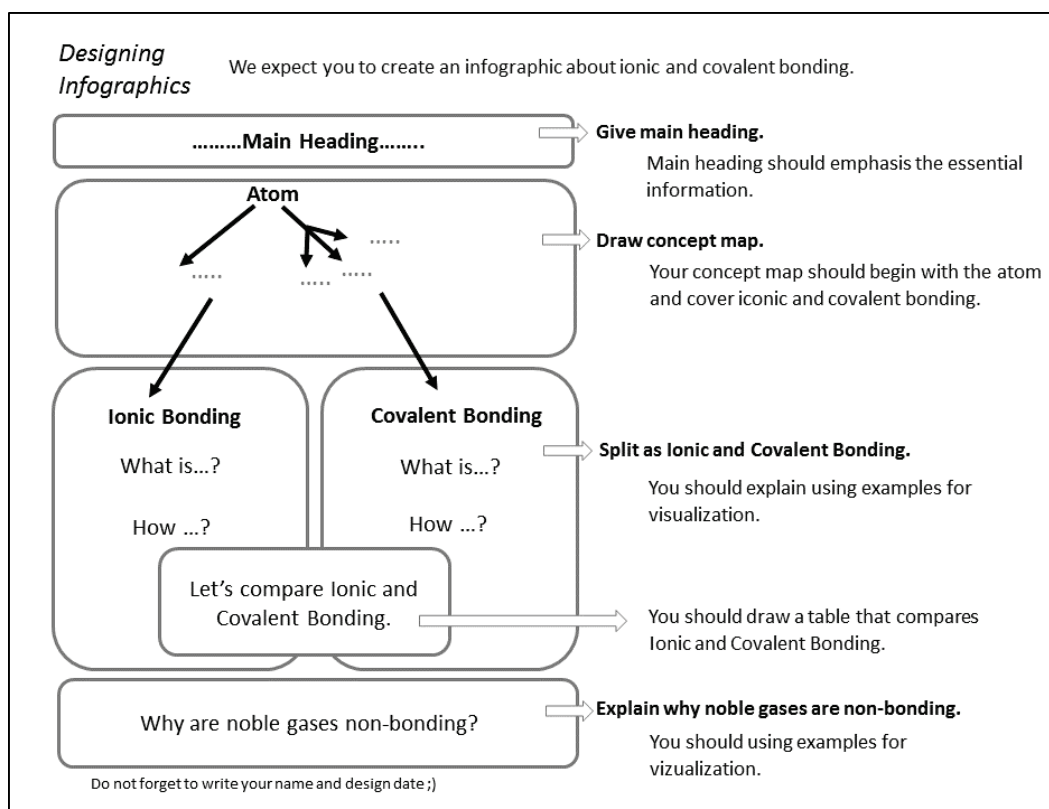

Figure 6. Infographic Design Project Instruction in the Second Meso Cycle

The digital design stage was conducted under the leadership of Information Technology teacher in partnership with the Visual Arts Teacher who had a good command of technology and the role of the technology design teacher. The Science and Technology teacher followed up the content of the students' infographic designs by providing them with feedback in their own lesson and in between lessons.

The Pages application was uploaded on the tablet. Starting from the formed drafts, students first transferred the big picture to the digital platform, placed headings and sub-headings and then returned to content generation and formed the explanations. They decided how the visuals should be by looking back at the content and drew visuals in the digital setting or used ready-made visuals.

Figure 7 contains pictures of students taken whilst they were designing infographics in the first and second meso cycles.
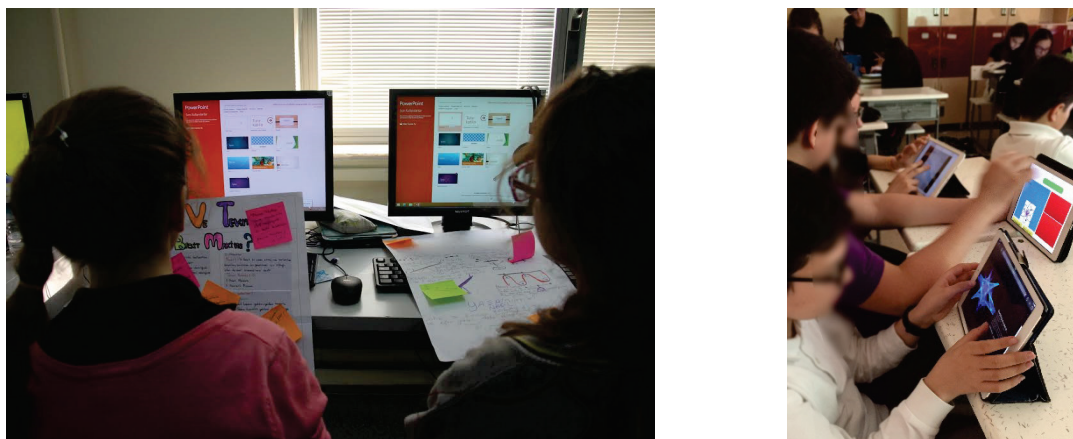

Figure 7. Students on their PCs (1st Meso Cycle), whilst working with their own tablets (2nd Meso Cycle)

Evaluation and Reflection

The second meso cycle implementation was evaluated in accordance with the infographic design levels, reflections of students and teachers and the focus group interview undertaken with teachers in addition to the first meso cycle. There was an increase in the visual design generation ($\bar{X}$=3.26) dimension in comparison to the first implementation (Table 5). Of particular attention was the level attained in the dimension of colors and visuals ($\bar{X}$=2.98). The results obtained in the measures of color effect on visibility of information ($\bar{X}$=2.74), and colour effect on redirection ($\bar{X}$=2.47) placed under the colors and visuals sub-dimension indicated that the design process needs to be improved with respect to these dimensions.

Table 5. IDR Results in the Second Meso Cycle

	$\bar{X}$	S.S.
Infographic Design	3.34	0.29
Content Generation	3.48	0.25
Main Heading	4.00	0.00
Sub-headings	3.58	0.51
Grouping	3.95	0.23
Systematics	3.68	0.48
Consistency	3.37	0.50
Essential Information	3.37	0.50
Key Concepts	2.74	0.87
Descriptions	3.21	0.63
Outcome	3.37	0.76
Identity	3.21	1.36
Visual Design Generation	3.26	0.39

Table 5. Continued

	$\overline{X}$	S.S.
Components/Big Picture	3.15	0.56
Visual Hierarchy	2.95	0.78
Redirection	3.21	0.79
Rhythm	3.26	0.65
Emphasis	2.84	0.69
Consistency	3.11	0.81
Balance	3.53	0.61
Integrity	3.16	0.90
Components/Text	3.65	0.23
Font Type	4.00	0.00
Font Color	3.74	0.45
Font Size	3.42	0.77
Font Case	4.00	0.00
Line Length	3.05	0.78
Line Spacing	4.00	0.00
Justification	3.37	0.68
Components/Colors and Visuals	2.98	0.53
Color Effect on Visibility of Information	2.74	1.20
Color harmony	2.74	1.10
Color Effect on Redirection	2.47	1.17
Background Color	3.16	0.69
Visual Reflection of Information	3.16	0.38
Reality Level of Visuals	3.26	0.45
Tags of Visuals	3.37	0.50
Components	3.31	0.34

A total of 68.42% of the students stated that they were able to place colors and visuals well on their infographics, 63.16% stated that they could form drafts well and 57.89% reported difficulty in placing objects in the tablet application (Table 6). A total of 47.37% of the students reported that the tablet and tablet application made the infographic design process easier, while 47.37% reported that the insufficiency of the tablet application was a factor that made the process more difficult.

Similar to student feedback, teachers reported that they were able to form the draft and the big picture with no difficulty and that they could work comfortably in the digital setting (Table 7). The Visual Arts Teacher stated that students had difficulty in forming visuals in the digital platform. The Information Technology teacher further reported that difficulties were experienced in sizing objects on the tablet screen and arranging them together. The teachers stated that the arrangement undertaken about the formation of drafts made the process easier. In addition, they reported that the students' ability to use their own devices, the presence of geometric shapes on the table application and the utilization of file transfer platform eased the process. It was pointed out that the insufficiency of the tablet application from a technical perspective and the inexperience of design on the touch screen caused difficulties in the design process.

Table 6. The Themes, Codes, Frequency and Percentages of Students' Reflections Regarding the Process in the Second Meso Cycle

Theme	Code	Freq.	%
Things I could do well when designing an infographic	Draft Generation	12	63.16
	Visual Design Generation – Components/Colors and Visuals	13	68.42
	Visual Design Generation – Big Picture	4	21.05
	Visual Design Generation – Components/Text	6	31.58
	Content Generation	5	26.32
Things I couldn't do well when designing an infographic	Placement of object in the tablet application	11	57.89
	Visual Design Generation - Components/Colors and Visuals Visuals	8	42.11
Things that made it easy for me to design an infographic	Tablet	9	47.37
	Tablet Application	9	47.37
	Instruction on what an Infographic is and How it is Designed	6	31.58
	Internet	3	15.79
Things that made it difficult to design an infographic	The Insufficiency of Tablet Application	9	47.37
	Insufficiency of Hardware	2	10.52
	Insufficiency of the Science Lesson	1	5.26
	Number of Students that Answered the Questions	19	100

Table 7. The Themes and Codes of Teachers Regarding the Process in the Second Meso Cycle

	Visual Arts (T_VA)	Information Technologies (T_IT)
Things students had no difficulty with whilst designing an Infographic	Draft generation and use of the grilling method	-
	Visual design generation (big picture)	
	Working in the digital setting	
Things students had difficulty with whilst designing an Infographic	Visual Design Generation (visuals)	
	Long Term Focusing	Sizing objects on the tablet screen and associating them with each other
	Visual Design Generation (color)	
Factors that make designing easy	Fast draft preparation in the A4 size and performing preliminary study on the screening method	
	Geometric shapes of the tablet application	
	Design on their own Instruments (Design on Tablets)	
	The use of the file transfer setting	
Factors that make designing difficult	Insufficiency of the Tablet Application	
	-	Inexperience of Design on the Touch Screen

The Visual Arts Teacher suggested that a preliminary study can be undertaken targeted at the formation of a color scale similar to the grilling application performed in the draft generation process from the second cycle. The Information Technology teacher stated that such an activity could be carried out over the online instruments that are already present:

"Color information needs to be really consolidated, pre-activities should be performed at that stage." (T_VA)

"Digital applications that enable the selection of color from a color wheel and the formation of scale could be used in order to prevent the problems student experience about color." (T_IT)

The Information Technology teacher stated that the difficulties stemming from the tablet application and students' inexperience in making designs on touch screens could be supported by pre-activities and that a visual formation application can be made in order to develop the picture-forming skills of students on tablets:

"Students had great difficulty in forming the visuals themselves, which also stemmed from the tablet application. However, if preliminary activities can be made in order to help them see the relationship between components, I believe they could form their visuals more comfortably whilst designing an infographic. It could also be suggested that they could form them in specialized different digital applications and add to infographics in order to visualize visuals. As such, a comfortable study space will be established on the entire screen. Additionally, they will also prevent the deterioration of other objects added to the infographics whilst they are engaged in the formation of the visual... " T_IT)

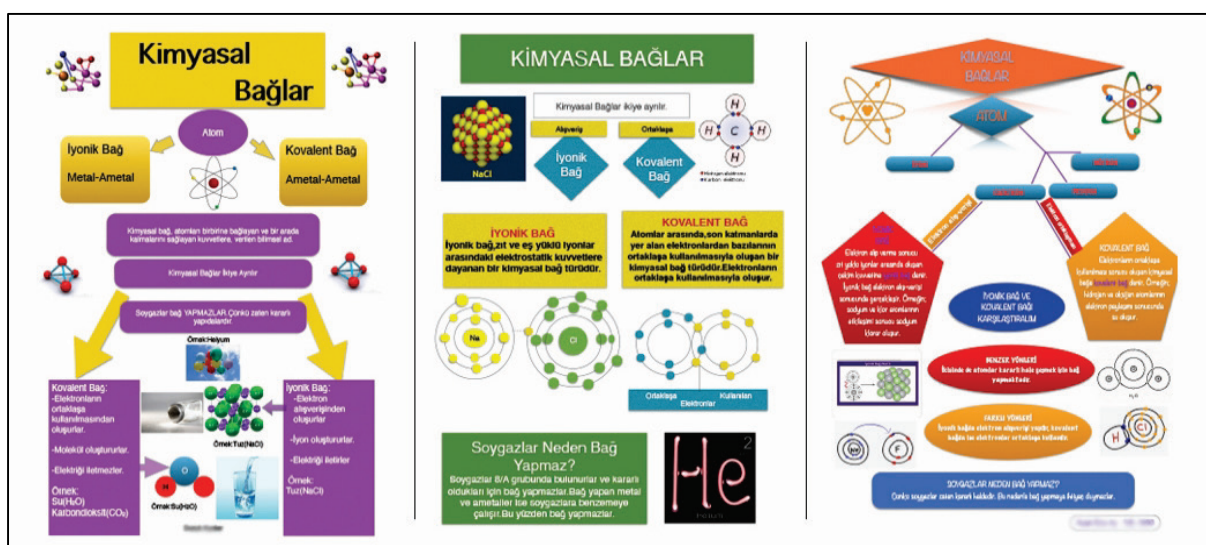Figure 8 contains examples of infographics designed in the second meso cycle.

Figure 8. Examples of Infographics Designed by Students in the Third Meso Cycle

The Third Meso Cycle

Following the first two meso cycles which consisted of the analysis and exploration, design and development and reflection and evaluation micro cycles, the third meso cycle contained the evaluation and reflection micro cycle in order to evaluate the implementation and design process in the first and second meso cycles.

Evaluation and Reflection

A focus group interview was held with all participating teachers to make a general evaluation of the process in the first two meso cycles. The focus group interview was carried out by the researcher, who was also the Information Technology Teacher. The interview took place under the general themes of cooperation between fields, insufficiency of time and the length of the design process, the realization

of the process in the lesson, the use of the students' own devices, implementation experience and the concurrent implementation with the subject examined.

Cooperation between teachers from different fields: The teachers stated that acting in coordination during the infographic design implementation is important in order to drive the process and obtain effective results:

> *"I very much believed in the importance of cooperation between the teachers from different fields. For instance, I need to sit in the Science and Technology lesson and listen so that I could give the right guidance to the child when designing about where to place what in the context of chemical bonds. The lesson could be listened to or needs to be looked up in the relevant material." (T_VA)*

> *"For example, my colleague can listen to one class and on another occasion we can go to their studios for support and thus achieve the most productive study" (T_ST)*

In line with the obtained findings, the role of the Science and Technology teachers was changed from active in the draft generation stage in the first meso cycle to inclusion in the process at the draft generation stage and providing feedback about the content as students carried our design in the digital setting in the second meso cycle in order to meet students' feedback needs and make more productive use of time. The Science and Technology teacher who participated in the second cycle emphasized that the design process could be supported in terms of content knowledge:

> *"I couldn't observe that our abstaining from entering the implementation process in the beginning in the second cycle had many shortfalls. Content wise, we gave feedback with the progression of time. If I was in between being active or inactive in the draft generation stage in with respect to the content generation dimension, there is not a thing that I could say this would be better, if I had done that." (T_ST)*

The Insufficiency of Time and the Lengthiness of the Design Process: Throughout the discussion, the teachers mostly reflected on the lack of time and the lengthiness of the infographic design process. It was stated that the first implementation was dispersed over a longer time frame in comparison to the second one and that students generally experienced hardship in focusing throughout studies that are long-lasting. They expressed the opinion that time was used more efficiently in comparison to the first implementation due to the arrangements made in the second implementation:

> *"There was an issue of inexperience in the first implementation, the process was all over the place, which was largely down to us... Therefore, the child couldn't help but distanced themselves from what was going on." (T_ST)*

> *"In the first implementation, we asked the child to form a draft on A3 sized paper using the scale that they actually need to see and the child fell apart there. The student tried to write down the subject by using pen and paper. It was difficult to both write and shorten the subject whilst at the same trying to combine it with visuals and form a composition." (T_VA)*

> *It is very difficult to make children focus on one subject for a long period of time. A conscious child knows what they are doing and shortens the process as such. A few of our students prepared their draft and came to the computer with everything ready. They also prepared everything on the computer and managed to observe the processes of their friends. In that sense, they used that period a lot faster in comparison to others." (T_ST)*

They reported that the arrangement made at the stage of draft generation in the second meso cycle was effective and that they could use time relatively efficiently. In addition, they stated that the use of the students' own devices and the use of common file sharing platform for accessing infographic designs speeded up the process:

> *"We resolved the time issue by transforming the draft preparation stage into a fast draft preparation. We directed the student who finished their fast draft within 20 minutes in the lesson to begin their designs in the tablets. (…) We resolved the issue of collecting the students' designs*

in the first implementation by using a common sharing area in the second implementation. It was easier for us to access the infographics. (…) In the second implementation, the child developed their infographic by not disintegrating, distancing themselves from the subject and not getting bored." (T_VA)

The realization of the process in the lesson: Due to time pressures in the first cycle, students were asked to carry out the draft generation and raw content stages at home. The Science and Technology teacher who took an active role in the first cycle stated that the setting of certain stages as homework was negative:

"When we first ran the implementation, we gave certain things to the child as homework and this had its shortcomings. The problem here is that unfortunately you can't make the child do even necessary homework. (...) In this implementation as well, he/she broke away from the subject and perceived that as an extra responsibility. As such, even if they enjoyed it, they thought of it as an extra workload." (T_ST)

In accordance with the findings obtained at the end of the first cycle, the process was re-arranged in the second cycle and all stages took place in the school. The teachers expressed positive opinions regarding the realization of all stages of the implementation in the school in the second cycle:

"He/she did everything related to the infographic study in the second implementation in the school. As such, he/she didn't break away much from the subject for instance." (T_VA)

"As they did everything in the school in the second implementation, it didn't represent an extra workload for them. In that case, they carried out the study with much more joy." (T_ST)

The Use of Own Devices by Students: The visual arts teacher evaluated the impact of tablets as positive on the realization of the process. The Science and Technology teacher found the process design to be more impressive in the second cycle:

"There were tablets in the second implementation which was different from the first one. We got out of the computer laboratory. We did not get into the hot water of changing classes. We planned such that everyone could work on their own tablet. We started to provide faster feedback" (T_VA)

".If it is carried out like it was in the second implementation, the infographic design process will be more useful" (T_FT)

Experience of using infographic design strategy: The Science and Technology teacher stated that infographic design was new for them as well and that experience was an important factor in carrying out the process"

"... Now that we all gained experience, the process will progress faster. And in fact, if there was no issue of inexperience the implementation in the first cycle could have been better." (T_ST)

Synchronous implementation with the taught subject: The Science and Technology teacher emphasized that the infographic design implementation needs to take place immediately after the teaching of the subject which will comprise the content of the infographic:

"(...) The child should have designed the infographic before the exam for that subject finishes. It shall be made in a serial manner immediately following the explanation of the topic and without lengthening the process to a great extent." (T_ST)

The Visual Arts teacher who took an active role in the second cycle reported that they were able to move more parallel to the topic in the second cycle:

"Is the topic finished? -Yes, it is. We said let's immediately start the design and got started on the design. The child didn't break away from both the subject and the design. (...) In that sense, our largest experience in the second implementation was the use of time relatively fast from all of our perspectives. We managed to restrict the time to a period of 3 weeks without spreading it over five to six weeks." (T_VA)

Conclusion, Discussion and Suggestions

In this research, the infographic design process as a learning strategy was modelled based on the educational design research method in accordance with two successive implementations that were carried out with 7th grade students enrolled in secondary school. The process was based on a tripodal structure consisting of the components of content generation, visual design generation and digital design. Both cycles contained the principle stages of "content acquisition", "content generation", "draft generation", "visual design generation" and "digital design".

In the design of the process, the learning situation and context formed the starting point and as such, the context was reflected in as much in depth as possible. The second meso cycle's process was amended in accordance with the findings reached in the first meso cycle. Based on their results in relation to learning status and context, both cycles presented an applicable infographic design process. The scrutiny of the presented infographic design process models and evaluation results in relation to the context will be an appropriate approach that suit the nature of the educational design research.

When the infographic design scores were examined from the perspective of the IDR sub-dimensions, those reached in the second meso cycle improved with the exception of a minor decrease in the text dimension (Fig. 9). It can be said that the most significant reason behind these improvements was the conversion of the sequential structure in the first meso cycle to a helical one in the second meso cycle. On the other hand, improvement in the visual design generation dimension is especially due to the activities that were included in the preparation phase of the application process in the second cycle that is intended to improve the visual design information level and ability. As Kos and Sims (2014) emphasizes, design process is highly impressed by the prior knowledge and abilities about infographic design of learners. It was seen that the positive change in visual design generation largely stemmed from the preliminary activities that took place in the preliminary training stage, the teacher experience obtained in the first cycle, the use of devices belonging to students based on the BYOD model and the expansion of time set for digital design in relation to this, the participation of the visual arts teacher in the digital design stage in collaboration with the visual arts teacher and hence the increase in the provided feedback.
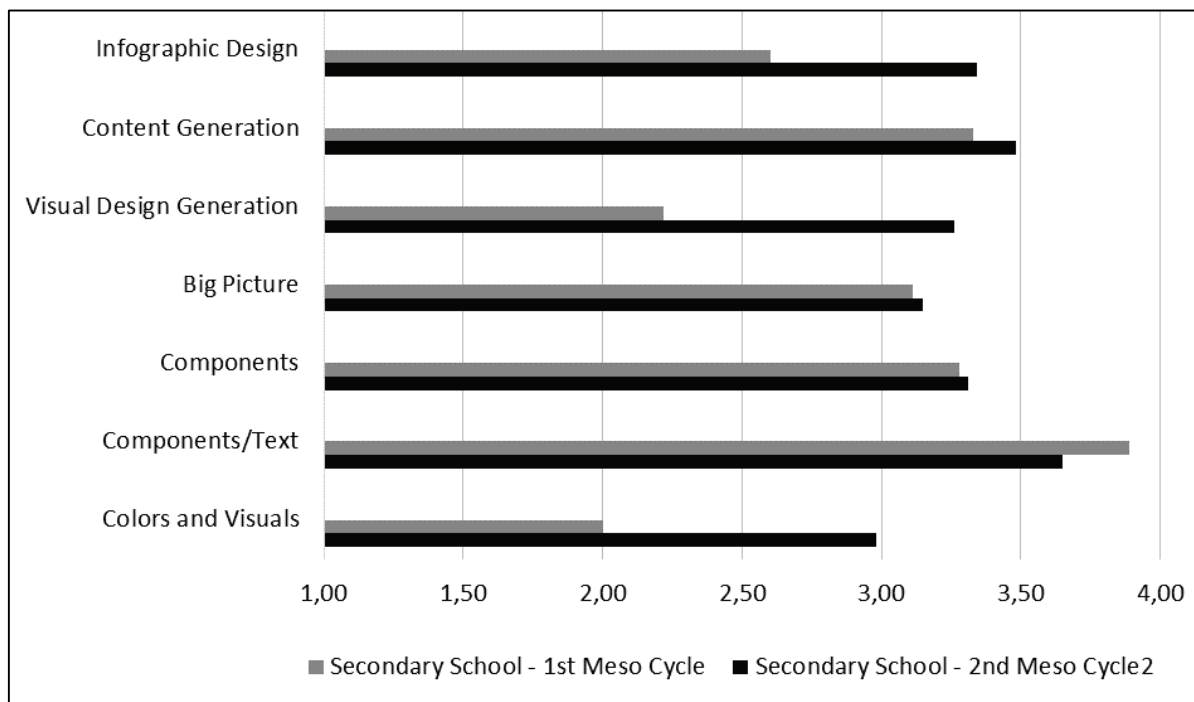

Figure 9. Comparison of the Infographic Design Scores in the First and Meso Cycle

In line with the evaluation results, the most significant change that was made in the second meso cycle was the students' use of their own tablets. The tablet application eased the process due to the BYOD method although the limitations of the design application and the inexperience of working on the touchscreen together with these limitations made the design process more difficult. Besides insufficiency of tablet application, using limited versions of them also causes difficulties (Kos & Sims, 2014). For learners that did not have experience working with high resolution in a small dimension, the absence of information and reflex relating to the use of the zoom in/out function on screen during the course of design was one of the difficulties experienced. It was observed that the object placements and sizes of infographics designed in the second meso cycle were significantly affected by the used instrument. At this point, the confinement of content that needs to be visualized, the assignment of faster, more narrowly-focused learning duties on tablet-sized devices and the implementation of a strategy based on the instrument can be a meaningful solution. In parallel to literature mentioned in accordance with the BYOD method (Alberta Education, 2012; Rogers, 2016), the students accessed the digital libraries established in the design process whenever they wanted, continued their designs at the time and setting they chose and had the opportunity to receive feedback from their teachers in times outside of the lesson. As they were able to use their own instruments more comfortably and easily with respect to both technical properties and the stored visual and textual materials, they mentioned in their reflections that working with tablets made the design processes easier.

When the designed infographics, the obtained findings and the development in between the cycles are taken into consideration, it can be argued that the infographic generating strategy may be used in the learning-teaching process. By conserving the principal stages of content acquisition, content generation, draft generation, visual design and digital design and taking into consideration the characteristics of learners and conditions in the helical structure, effective results can be obtained.

Suggestions Regarding the Implementation

The timing for the infographic generation process can either be made according to the content or the content on which the infographic will be developed can be limited based on the planned timeframe. In order to implement the suggested infographic design strategy, the teacher should have the competency in order to develop the infographic or plan the process in such a way that it could be carried out in cooperation with the relevant fields. The arrangement and development of the preliminary training stage in accordance with the knowledge and competence of learners will affect the success of learners in the design process to a significant extent. The provision of feedback regarding shaping as much as possible in order to enable learners to effectively complete the infographic design stages will support the learning and infographic generation process to a significant extent. If the learning setting is suitable for learners to carry out the process using their own instruments or such a setting can be formed, it could be supported by using developed infographic design instruments via the BYOD method.

Suggestions Regarding the Research

The two cycles in the research were carried out with teachers and students encountering the concept of infographic for the first time and as such teaching infographics and information design principles comprised a significant portion of the preliminary training process. In future studies, the process could be undertaken with teachers and learners with experience in infographic design and the infographic design implementations conducted by the teachers in their own lessons can be observed to further adjust the infographic design model. By undertaking a longitudinal study, the skill development of students regarding infographic design can be determined. A fast infographic design process could be modelled in order to visualize relatively less complicated information in the learning process. Studies in which infographic generation strategy is used as an inter-group information visualization instrument for collaborative learning settings could be carried out.

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