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Assessment of Creativity in Artifacts Designed by Gifted Students: A Social Semiotic Multimodal Perspective

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Abstract

Creativity is a central trait of giftedness, making the assessment of creativity an essential endeavor. A socio-cultural perspective takes into account all aspects of the social environment in which creative products emerge and underscores the necessity of considering these aspects when assessing such products. Regarding gifted classroom as a socio-cultural context, this study aims to introduce a systemic approach to evaluating creativity in designs created by gifted students, considering the multimodal discourse practices within the classroom. A qualitative descriptive method was employed, involving 16 fifth-grade gifted students in the study. Data were collected through participant design of artifacts and analyzed using multimodal and semiotic richness analysis. The results indicate that the analyzed texts are predominantly rich in semiotic aspects and demonstrate the effectiveness of the evaluation tool in assessing creativity in designs based on the discourse nature of the gifted students' science classroom.

Keywords: artifacts, creativity, gifted students, multimodal design, social semiotics

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Introduction

Giftedness is described from various perspectives including intellectual and non-intellectual variables concerning learning, training, and practicing which transform basic, genetically determined gifts into specific talents in daily life (Kaufman & Sternberg, 2008). According to the three-ring model of Renzulli (2005), giftedness melts well-above-average ability, creativity, and task commitment into the same pot. Similarly, Kaufman and Sternberg (2008) propose that creative people typically have above-average intelligence, and Runco and Albert (1986) posit that creativity is the highest form of giftedness. Therefore, creativity has been identified by many as an important indicator of giftedness (Plucker et al., 2018). In this respect, creativity is considered one of the main traits of giftedness, and gifted students are expected to produce creative learning products

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in the classroom (Bailey et al., 2016). As such, gifted students are considered to have higher-order cognitive abilities including creative abilities in the classroom. These creative abilities are also viewed from different perspectives which are divergent thinking, convergent thinking, flexible creating process, and creative artifacts. Creative abilities are demonstrated through many recognizable human actions and artifacts in a socio-cultural context (Csikszentmihalyi, 1988; Glăveanu, 2010).

Assuming that creativity is a central component of giftedness, the provision of gifted students may include pedagogical strategies to support creativity. In this respect, Besançon (2013) expresses that, in the gifted classroom, creativity needs to be valued at least as much as knowledge acquisition. As such, numerous research has explored creativity in the gifted classroom. Creativity researchers have studied descriptions and characteristics of creativity and creative potential (e.g., Amabile, 1996; Csikszentmihalyi, 1988, 1999; Glăveanu, 2013; Guilford, 1967; Rhodes, 1961; Stenberg & Lubart, 1995), the relationship between intelligence and creativity (Sternberg et al., 2001), the different kinds of pedagogical strategies for fostering creativity in the classroom (Clifford, 1988; Demetrikopoulos & Pecore, 2016), characteristics of creative individuals within domain-general and domain-specific perspectives (Plucker & Beghetto, 2004), the cognitive resources of creativity including thinking styles and flexibility (Stenberg & Lubart, 1995), and the environmental factors that affect creativity (Lubart et al., 2003). Furthermore, the assessment and evaluation of creativity in human actions, thoughts, or products is another prominent topic in the relevant research field (Plucker & Makel, 2010).

Assessment of creativity has been explored from various perspectives as well. In this vein, there have been numerous conceptions of creativity and methods of measuring creative output. These perspectives firstly include personality assessment which focuses on the personal characteristics of creative persons or creative gifted persons (Basadur & Hausdorf, 1996; Davis, 1992). The second perspective or approach is related to process and cognitive assessments which include divergent thinking tests such as the Torrance Tests of Creative Thinking (Torrance, 1976) and the Evaluation of Potential for Creativity (Lubart et al., 2011), and questionnaires on creative abilities (Milgram & Hong, 1999). Third, environmental assessments focusing on the environmental factors that influence creativity were explored (Amabile, 1996; Csikszentmihalyi, 1988, 1999). Finally, the assessment of creativity perspectives involves product assessment where the creativity is assessed by the products or artifacts designed by the individuals. A prominent example of a product assessment method is the Consensual Assessment Technique (CAT) of Amabile (1983). Regarding the assessment of creativity in products, Plucker et al. (2018) put forth that measures of creative products have been examined many times for reliability, but validity remains an issue, in part because there is no universally accepted criterion of creativity.

Regarding the previous studies on creativity, by foregrounding the embedded and extended nature of cognition in its socio-cultural setting, Glăveanu (2013) posits that creativity research is generally done by isolating or detaching the individuals from their socio-cultural contexts. From a system perspective (Csikszentmihalyi, 1988; Rhodes, 1961), Glăveanu (2013) reports that creativity must be considered within the elements of the socio-cultural systems that the person is embedded in not as a phenomenon taking place in the person's mind or cognition. This issue also engages the assessment of creativity which is also mostly handled in an isolated approach that is unable to assess the creative properties concerning the socio-cultural setting. Deeming that products are products of a cognitive process, deeming that cognition is extended and embedded in the socio-cultural setting, and products are results of psychological and cultural objects, the assessment techniques generally omit an approach that fits the intersections, and generally omit one. In this respect, as the assessment of creativity is a major component of fostering creativity in the classroom (Besançon, 2013; Plucker & Makel, 2010), this study focuses on the assessment of creativity in learning products concerning a socio-cultural context which is the gifted classroom.

Purpose of the Study

This study aims to investigate the creativity in learning products designed by gifted students in the science classroom. For this purpose, the current study looks for employing an evaluation tool for exploring creativity in learning products about meaning-making practices in the discourse system of the science classroom and evaluating the creativity of the deployed semiotic resources deployed in the learning products. In this aim, the learning products or artifacts designed by gifted students in the science classroom are assessed regarding the meaning-making practices in the specific discourse system of science and science classrooms. By sketching a multimodal description of the meaning-making practices and discourse system of the science classroom as a social-cultural context of the artifacts, the evaluation tool is expected to assess the creativity of the semiotic properties of artifacts.

What the study brings new is adopting a social semiotic multimodal perspective (Kress, 2010) to evaluate creativity in the learning products as student-designed artifacts. This perspective is important for inspiration regarding the assessment of creativity in learning products designed in classroom activities as a socio-cultural context for teachers and students. In this way, the creativity in learning products is assessed in terms of semiotic properties of representational practices and choices made by students in their learning products as artifacts.

Theoretical Framework

The study is informed by the 5A model of creativity (Glăveanu, 2013) which socio-cultural perspective to theorize and explain creativity. Secondly, for describing the nature of classroom discourse and representational practices, social semiotics, and multimodality (Kress, 2010) guide the theoretical backdrops.

Creativity

Creativity is defined according to various perspectives. In general terms, creativity can be defined as the capacity to produce something new and adaptive within the constraints of a given situation (Lubart et al., 2003). But Barron (1995) posits that “creativity is not a rootless flower," (p. 9) by emphasizing the ecology of creative expression. This expresses that creativity is not a phenomenon taking place solely in the cognition or mind of the person but related and extended to the natural and social world where the person exists and acts. This view is pertinent to cultural psychology which is the study of the way cultural traditions and social practices regulate, express, transform, and permute the human psyche" (Shweder, 1990, p. 1). In this respect, cultural psychology deals with *cultured* constitution and expression of the human mind and creativity cannot be isolated from this cultured expression. In this line, Plucker et al. (2004) propose that "creativity is the interaction among aptitude, process, and the environment by which an individual or group produces a perceptible product that is both novel and useful as defined within a social context" (p. 90). This is specifically pertinent to understanding a phenomenon like creativity in which the person is embedded in/acts from within a system of social relations and the activity of creation produces meaning by integrating and transforming types of knowledge that, although individual in expression, are social in origin (Glăveanu, 2013).

In this respect, in exploring the creativity in the gifted classroom, and in exploring the creativity in learning products designed by students, we need to consider the socio-cultural setting where students are embedded both socially and materially. Regarding learning in the classroom as the socio-cultural setting, from a Vygotskyan perspective, Wertsch and Stone (1985) deem learning as a construction rather than a process of direct transmission or copying and posit that, for an individual, learning depends on mastery (internalization) of the cultural system of symbolic representations. Similarly, Engeström (1999) remarks that internalization is pertaining to the reproduction of culture and externalization can be considered as the process where the creation of artifacts takes place to transform the culture which is considered a human creation. Regarding these transformed creations, many scholars view learning products as student artifacts designed through learning activities (Andersen & Munksby, 2018; Jewitt et al., 2001a; Waldrip et al., 2010), and knowledge is demonstrated through representations (Wartofsky, 1979). Therefore, in exploring the creativity in learning products one should remind that the learning products are emerged in such a socio-cultural and psychological process taking place in the classroom settings.

This study adopts the 5A model of creativity of Glăveanu (2013). The Five-A framework of creativity engages Actor, Action, Artifact, Audience, and Affordance to theorize and study creative acts. The model concerns "the action of an actor or group of actors, in its constant interaction with multiple audiences and the affordances of the material world, leading to the generation of new and useful artifacts" (Glăveanu, 2013, p. 76). In referring to actors, the current paper acknowledges gifted students as socialized selves, as beings that are shaped by a socio-cultural context (science classroom) and act from within it, in coordination with others (peers and teachers), to change and mold this context in suitable ways. Audience refers to the social aspect of the environment, and affordance refers to the material aspect of the environment including the material opportunities in creating an act. In classroom settings, the former can be teachers' and peers' reviews and comments, and the latter can be resources such as books, computers, or other materials. Action is considered as both psychological and material, internal and external, goal-directed, structured, and symbolic or meaningful. Ginsburg (1980) states that "human action necessarily is situated; it occurs in a context" (p. 333). In this respect, creative action emerges out of actor–audience relations that both produce and are mediated by the generation and use of new artifacts (objects, signs, symbols, representations, etc.) within a physical, social, and cultural environment. Therefore, the student act of creating is the action that is done in the socio-cultural setting of the classroom concerning other social selves as teachers and peers. Some actions in the classroom can be teaching, learning, and engaging extracurricular activities. Finally, artifacts are the result of the creative action or process, which includes not only perceptible items such as buildings, paintings, and inventions but also creative ideas that can be embodied into tangible forms.

Creativity in Artifacts as Student Learning Products

The science classroom is a socio-cultural context and culture is seen as an accumulated system of symbolic and material human creations (Cole, 1996). According to this assumption, the discourse of science involves its representational practices and meaningful artifacts or representations for meaning-making and communication of scientific knowledge. This discourse involves teaching and learning activities as actions. Regarding the creative act as a human activity and learning to engage in internalization and externalization, student-generated artifacts can be seen as the externalized and materialized product of creative action. Moran and John-Steiner (2003) "externalization is the construction and synthesis of emotion-based meanings and cognitive symbols, and once expressed, these meanings and symbols are embodied in cultural artifacts" (p. 63). Therefore, the creative artifact is a product of cultural participation and thus an artifact or cultural *object* (Glăveanu, 2010). In other words, Glăveanu (2013) notes that "each creation or product comes into being, is understood, and is valued as part of a larger web of relations of people, things, institutions, and beliefs beyond that particular creation" (p. 74). What is new is form transformed; a new form, generated from an old one existed in the social environment. Therefore, the meaning and the creative potential in materialized student-generated learning products can be understood in the discourse of the science classroom and the discourse of science.

The Multimodal Nature of Discourse in Science Classroom

Artifacts are seen as the part or product of such a socio-cultural system, and this study explores the creativity of these artifacts in an assessment framework that fits with the socio-cultural approach. As such, assessment and evaluation of creativity in artifacts designed by gifted students cannot be understood until encoding the meaning related to the discourse of its context and meaning-making practices and how an artifact should be creative within its socio-cultural context, which is a science classroom. When referring to a study of creative artifacts, it has been noted that current techniques are overconcerned with the measurement of properties and evaluation of creativity and fail to consider artifacts in the broader context of meaning-making processes taking place between actors and audiences in particular socio-cultural settings. In this respect, this study aims to do this regarding the representational tools and resources taking place in the discourse system of the classroom. This engages focusing on the learning products designed by gifted students in the science classroom by evaluating the creativity in relation to the discourse system of socio-cultural context with an analysis of semiotic properties of artifacts.

The discourse of science is characterized as multimodal (Yeo & Nielsen, 2020), and multimodal representations are crucial tools for meaning-making and knowledge production. In this process, multimodal representations become essential "tools for meaning-making and knowledge production" (Prain & Waldrip, 2010, p. 1). As such, the nature of meaning-making processes in the discourse system of socio-cultural context is multimodal where the internalization and externalization take place through multimodal artifacts. Therefore, the construction and communication of scientific knowledge are considered multimodal where various modes including language, visual imagery, mathematical symbolism, or gestures are deployed (O'Halloran, 2007). In parallel, Waldrip et al. (2010) note that the discipline of science should be understood "historically as the development and integration of multi-modal discourses" (p. 66) and "where different modes fulfill different needs regarding reasoning and recording scientific inquiry" (p. 66). As such, scientific representations of artifacts are multimodal ensembles that are comprised of various semiotic resources and modes. The design of scientific representations/artifacts involves the deployment of these semiotic resources within certain aforementioned modes. Therefore, the analysis of these artifacts involves the deconstruction of semiotic resources or signs within various modes and how they are composed in the text.

Multimodal Design and Creativity in Artifacts

According to the social semiotics account of learning, the process of learning is a communicational and societal phenomenon that takes place through the re-construction and re-contextualization of meanings mediated by semiotic resources (Jewitt, 2008). This re-contextualization and re-construction include student internalization and externalization which is materialized process involving design (Lemke, 1990). Externalization is a design process that involves "the ability to select, produce and productively use representations but also the abilities to critique and modify representations and even to design completely new representations" (DiSessa & Sherin, 2000, p. 387). Furthermore, Azevedo (2000) proposes that when students design representations, they come up with new inscriptional tools and develop their creativity and demonstrate their abilities.

Kress's (2000) theory of *design* accounts for how the meaning-maker (here gifted student) integrates the different representational choices in artifacts. Kress (2000) argues that "design is thus both about the best, the aptest representation of anyone's interest; and about the best means of deploying available resources in a complex ensemble" (p. 158). This proposition is concordant with Cox (2005) who states that children's abilities are not only affected by their level of motor control and cognitive development, but also by their intention and their socio-cultural context. Within this design conception, Kress (1997) argues that different children have different dispositions and preferences for self-expression. As Kress (1997) notes:

> Children see the complexity of the meaningful cultural world with absolute clarity; and in their making of meaning, they construct elaborate, complex representations of that world – out of the materials which are to hand... In this process, they construct complex alternative systems of representations, never arbitrarily, never simply copying, always producing forms which reveal and bear the logic and interest of their sign-maker's cognitive actions and affective interests. (p. 33)

In this respect, the creative artifacts designed by gifted students in the classroom must be evaluated in a way that sees that the student is internalized the accumulated sign system of the discourse system and externalized it in terms of her/his abilities, interests, or preferences. A creative actor is arguably one able to exploit the affordances of his or her surroundings innovatively, discover new affordances, and even create the ones needed to fulfill a specific action (Glăveanu, 2012). Multimodal design of learning products as artifacts, Bock (2016) notes that guided by social semiotic theories of communication, multimodal pedagogies, and cognitive accounts of artifacts, how students work easily and seamlessly across a variety of materials and modes, using the semiotic resources available in their environments, "to create imaginary worlds and express meanings according to their interests". In Newfield's (2009) terms, students' utilizing a range of semiotic resources (representational choices) to design artifacts, is a *transmodal moment* (italic added) a moment when students' "sense of design and interest guides their choice of mode, and results in a transformation of meaning" (Bock, 2016, p. 14).

These moments engage resemiotisations where students express their understanding or knowledge with different semiotic resources (Bock, 2016). In this respect, Stein (2003) argues that these resemiotisations are the key to *unleashing* children's creativity, reshaping their knowledge, and stimulating learning. Stein refers this to Hofstadter's (1985) argument that "making variations on a theme is the crux of creativity" (p. 233): as the concept or idea passes from one mode to the next, it develops in ways that are unexpected and unanticipated, thereby enabling multiple variations (of forms, shapes, colors, patterns, words, and images) to emerge. In this respect, the variety in semiotic resources, modes, and representation in demonstrating an understanding of content can be seen as a creativity measure in artifacts. However, in the words of Csikszentmihalyi (1999), "one must internalize the rules of the domain and the opinions of the field so that one can choose the most promising ideas to work on and do so in a way that will be acceptable to one's peers" (p. 332). This means that, besides the variety in use, the deployed semiotic resources must make meaning in the discourse system of the science topic and science classroom. In this respect, the student's capability to produce something new and adaptive within the constraints of a given situation emerges.

Semiotic Richness of Artifacts as a Measure of Variation and Creativity

The concept of semiotic richness is developed by Gebre and Polman (2016) to explore the variety in the creative use of semiotic resources (representational choices) to make meaning in the design of artifacts. Semiotic richness is seen as the effective and creative deployment of representations (or semiotic resources) in artifacts that are multimodal in nature. The creativity aspect deals with the distinct and effective deployment of various types of verbal and non-verbal representational choices which communicate distinct messages. What is more, these representations are complemented and co-operated with each other to construct a unified and complete scientific knowledge. Such a construction of multimodal artifact engages creativity in design since the text does not include parsimonious, distinct but related representations and uniqueness across representations demonstrating a whole message (Gebre & Polman, 2016). Semiotic richness is measured by the dimensionality of artifacts. In this respect, Gebre and Polman posit that the dimensionality of artifacts is seen as a measure of creativity in design through which students demonstrate scientific knowledge with the deployment of various material-semiotic resources of meaning-making. As such, the variety in the representational choices can be seen as the creative deployment of resources in the artifacts and the semiotic richness level can be seen as a criterion for evaluating the level of creativity in these artifacts.

This paper, then, explores the different ways in which gifted students utilize a range of semiotic resources (representational choices) including modes (verbal and non-verbal) and different types of representations to demonstrate scientific knowledge. In this respect, this study aims to explore creativity in science representations or artifacts designed by gifted students in science classrooms regarding the discourse system and meaning-making practices of the science classroom as a socio-cultural context. In this line the research questions of the research are determined as follows:

1. What are the representational choices in the construction of scientific knowledge as in fifth-level gifted students' design of science artifacts related to the solar system?
2. What is the level of creativity in the design of scientific knowledge regarding representational choices in fifth-level gifted students' design of science artifacts related to the solar system?

Method

This study is descriptive qualitative research that entails multimodal discourse analysis (Tang & Danielsson, 2018) of multimodal science texts designed by gifted students in the science classroom. Braun and Clarke (2019) state that qualitative research does not provide a single and universal answer, it attaches great importance to context and can be empirical or critical. There is an ontological approach that guides every qualitative research. This ontological approach assumes that reality is independent of or constructed by human cognition. The ontological approach adopted by this research is the approach put forward by the constructivist philosophy (Savin-Baden & Major, 2013). According to the constructivist approach, knowledge is constructed and developed by the individual's building of new knowledge on his previous knowledge and experiences through his own life (Savin-Baden & Major, 2013). To answer the first question, the variety in verbal and non-verbal representational choices is analyzed. To answer the second question, students' design of science texts/artifacts is analyzed according to the semiotic richness concept of

Gebre and Polman (2016) to reveal the variety in the use of semiotic modes and representations and how effectively they are deployed in the artifacts.

Procedure and Research Process

This study is conducted with the participation of a science teacher and 16 fifth grade gifted students in the 2021-2022 fall term. The students studied at a formal school of gifted and talented. Admission to the school, where the participants study, involves IQ tests and ability tests. Students voluntarily designed artifacts in the science classroom and they are informed about the context of the research. The research was conducted after the teaching of the solar system subject. The topic of the solar system is a part of their curriculum. The teaching of the subject took two lessons. In the lessons, the teacher lectured the subject through oral representation and PowerPoint presentations. After two lessons, the teacher asked students to design representations of the solar system. Students used pseudonyms for the texts. The design of the representations took one lesson. After students designed the representations of the solar system, the teacher delivered the texts to the researcher. The researcher did not participate in the classroom setting. Since the texts are given with pseudonyms to the researcher and there were no identifiers on the texts (artifacts) confidentiality was kept. Furthermore, because this study employs a text analysis no questions are asked, and no extra data was collected.

Data Collection and Analysis

The data is comprised of 31 multimodal artifacts designed by gifted students. Each student designed two artifacts, except one. The artifacts were designed after the science teacher introduced the subject. As science artifacts are multimodal, multimodal representational analysis is adopted for data analysis. This strategy can reveal the representational value of text regarding constituent semiotic resources and text arrangement. In this paper, the analysis of multimodal texts involves two stages. The first stage involves the determination of representational variations (the number of different representation types) in the science artifacts. The second stage involved figuring out the semiotic richness of the designed artifacts. After these two stages, it is observed how gifted students use various representational choices to demonstrate scientific knowledge creatively.

Representational Variations

The representational variations are determined in the following way: Representations are first categorized as linguistic (written language) and non-linguistic representations. Next, the non-linguistic representations are classified into three groups: iconic/symbolic, schematic, and mathematical (i.e., charts and graphs). According to Lemke (1998), iconic representations are signs that have a physical resemblance to their referents for example, images representing walking or turning right. Further, these representations can signify processes, participants, or circumstances in which they maintain a similar physical structure. O’Grady and O’Grady (2008) state that symbolic representations are abstract signs that are based on socially generated symbol systems and do not have any physical or structural resemblance to what they represent. For example, the symbol for *nuclear* *danger* is a symbolic representation that does not have any physical resemblance to the referent. Secondly, schematic representations function to "identify components and represent hierarchies, and flow of processes" (Gebre & Polman, 2016, p. 2674). Flowcharts and organizational charts are viewed as exemplary cases of this kind of representation. Finally, charts and graphs are representations that demonstrate the quantitative relationships between entities or participants. Gebre and Polman (2016) also state that this kind of representation is good for concretizing abstract data. Examples of this category are line graphs, pictographs, tables, or bubble charts. The variety in the deployment of these representations and their types is an indicator of creativity in the designed artifacts.

The Dimensionality of Representation as a Parameter of the Semiotic Richness of Representations

Figuring out the dimensionality of representation starts with determining the communicative functions of each type of non-verbal representation in the artifacts. This is done by describing the purpose of each representation in terms of how much information or knowledge it demonstrates. In other words, for what purpose does each representation stands for? Does the used representation provide different information or repeat the same information with another representation deployed in the artifact? Gebre and Polman (2016) express that these questions can be answered by determining what information or knowledge is communicated with each representation within the artifact. This data helps to figure out if the used representation provides new information or repeats information presented by other verbal or non-verbal representations in the artifact. The dimension is viewed as an "aspect of the represented topic that is communicated by one type of representation." Therefore, the higher number of dimensions refers to the efficient and economic use of representations or semiotic resources in a non-repetitive (redundant or parsimonious) way for the construction of scientific knowledge in the artifact.

The dimensionality ratio is calculated by dividing the number of non-verbal representations (D) by the total number of non-verbal representations [R(f)]. The dimensionality ratio ranges from less than 1, equal to 1, and greater than 1, which means that one or more of the used representations communicate more than one piece of information. In addition, as mentioned above, semiotic richness is seen as the effective and creative use of representations. The creativity aspect deals with the use of various types of verbal and non-verbal representations that communicate different types of information or knowledge. Therefore, the dimensionality ratio is an indicator of semiotic richness, which refers to the creative deployment of various representations. Therefore, creativity is both related to variations in representational choices and the effective use of these choices in demonstrating scientific knowledge. As such, artifacts that have a dimensionality ratio equal to or greater than 1 are considered creative. What is more, these representations complement and cooperate with each other to construct a unified and complete representation of scientific knowledge. Such a construction of a multimodal artifact engages creativity in design since the text does not include parsimonious, distinct but related representations, and uniqueness across representations demonstrates a whole message. Regarding the above-mentioned strategy presented by Gebre and Polman

(2016), a multimodal representational analysis chart is developed (see Figure 1). The chart is used to analyze the multimodal representational choices and creative deployment of them in artifacts. The chart provides quantitative data about one artifact's representational variety and semiotic richness.

Figure 1

The Chart for Multimodal Representational Analysis of Artifacts

<table>
<tr><td colspan="2">Verbal Reps.</td><td colspan="7">Non-Verbal Representations</td></tr>
<tr><td colspan="2"></td><td>R(f)</td><td colspan="3">Representation Type</td><td>Iconic/
Symbolic</td><td>Schematic</td><td>Graph/
Chart</td></tr>
<tr><td>Related</td><td>Non-Rel.</td><td rowspan="2"></td><td>1</td><td>2</td><td>3</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="4">Number of Dimensions (D)</td><td colspan="5">Dimensionality Ratio (D/R)</td></tr>
<tr><td colspan="4"></td><td colspan="5"></td></tr>
</table>

Trustworthiness

To determine the reliability and validity of the data analysis tool, the following procedure was followed: In parallel to Smith et al. (2013) and West et al. (2013), the tool for semiotic and representational analysis was developed, and to test the reliability of the tool, the procedure of Rui and Feldman (2012) was followed. Observation criteria and codes of the observation criteria, as previously mentioned, stem from the multimodal semiotic analysis and empirical study of Gebre and Polman (2016). Therefore, the primary criterion for the validity of the tool is the theoretical and empirical basis of previous research in multimodality and creativity. The reliability of the data analysis tool is tested by intra-rater and inter-rater reliability procedures. For intra-rater reliability, the same researcher analyzed two texts at two distinct times (a one-week gap). For inter-rater reliability, two researchers, who are experienced in the field, analyzed the same two texts and made a comparison for the similarity and consistency among the given categorical codes. I employed Cohen’s Kappa test to see the consistency and similarity between codes. Intra-rater and inter-rater reliability scores are given in Tables 1 and 2 below.

Table 1

Kappa Results of Intra-Rater Reliability

	Verbal Relation	No Different Representations	Representation Types	Frequency of Representations
Text 1	.878	.839	.726	.863
Text 2	.859	.816	.841	.875

Table 2

Kappa Results of Inter-rater Reliability

	Verbal Relation	No Different Representations	Representation Types	Frequency of Representations
Text 1	.678	.749	.736	.843
Text 2	.759	.846	.731	.865

Findings

The analysis of texts is done in both quantitative and qualitative aspects. In the first part, quantitative data is presented. The quantitative data includes (1) frequencies of representational choices in all artifacts, (2) frequencies of artifacts regarding included non-verbal representations, (3) frequencies of deployed non-verbal representation types, and (4) dimensionality ratios of the non-verbal representations. The first three monitor the variety in the representational choices and, therefore, address the first research question. The latest indicates the semiotic richness that functions to answer the second research question. In the second part, four exemplary cases of student texts are demonstrated and qualitatively analyzed. In Figure 2 below, the frequency of representational choices for all 31 artifacts is represented. Data demonstrates that there are a total of 389 representational choices, and among these choices, 151 of them are verbal representations, which corresponds to 39%. 15 of these verbal choices are not related to non-verbal representation. Being related means that verbal information complements another representation or simply repeats others. Data demonstrates that 238 (61%) of the representational choices in all artifacts are non-verbal, including symbolic/iconic, schematic, or mathematical (graphs, charts, etc.) representations. Almost all verbal and non-verbal representational choices are related to each other in constructing scientific knowledge. This demonstrates that verbal and non-verbal representations complement each other when demonstrating information. In a different view, language mode and visual imagery mode are generally interacted with and integrated into designed artifacts.

Figure 2

Frequencies of Representational Choices in All Artifacts

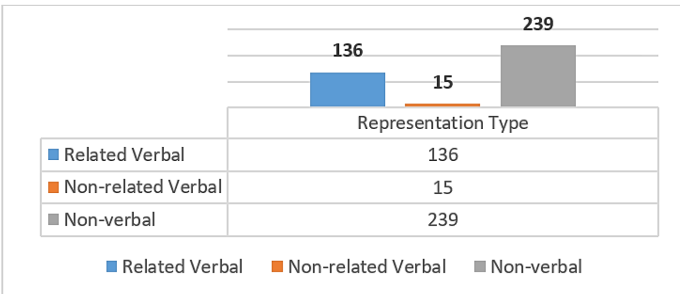


Figure 3 below demonstrates the frequency of artifacts in terms of how many different non-verbal representation types they include. 20 of the 31 texts are included with one type of non-verbal representation and one type of verbal representation. This data demonstrates the variety of non-verbal representational choices in artifact designs. It can also be said that the deployment of representation types is somehow dependent on the subject or the topic. Since the subject of the solar system does not involve, for example, many symbols or icons in comparison to the subject of kinetic energy, the designs involve limited icons or symbols. What is more, since the subject is observable phenomena, students mostly opt to draw these phenomena schematically.

Figure 3

Frequencies of Artifacts Regarding Included Non-Verbal Representations

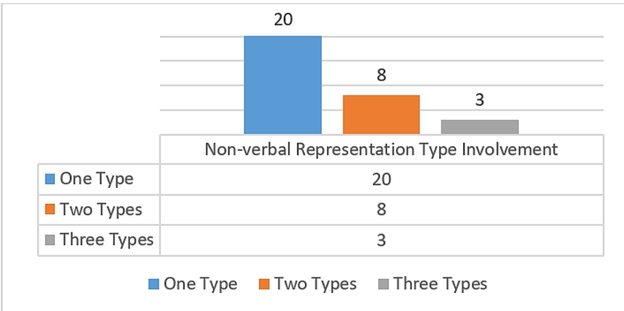


Figure 4 below displays the frequencies of deployed non-verbal representation types in all artifacts. 73% of the non-verbal representations are schematic, 24% are iconic or symbolic, and only 3% are mathematical representations, including charts or graphs. As stated early, schematic representations depict realistic physical phenomena as closely as possible to the referent. Students mostly preferred to demonstrate the solar system and states of the moon as they are shown and as they see them in daily life. The low amount of use of mathematical representation is due to the absence of quantitative or mathematical relations between the entities taking place in the subject matter. Students are expected to demonstrate the physical utterances in their way of understanding, and any information, including, for example, a mathematical comparison of sizes, is not required. Nevertheless, some students demonstrated the distances between the planets and the sun and compared them with mathematical representations. The iconic or symbolic representations mostly include icons for stars, mathematical signs, or icons demonstrating humans. Icons are generally used instead of verbal representations in schematic representations. For example, students drew sticky human icons rather than writing humans next to schematic representations. This result demonstrates the variety in the use of representation types and semiotic resources in different modes, which is an indicator of creativity in the designs. All the designed artifacts involve at least one non-verbal representation, which means that in externalizing scientific knowledge, multimodal artifacts are designed in accordance with the multimodal discourse of scientific knowledge.

Figure 4

Frequencies of Deployed Non-Verbal Representation Types

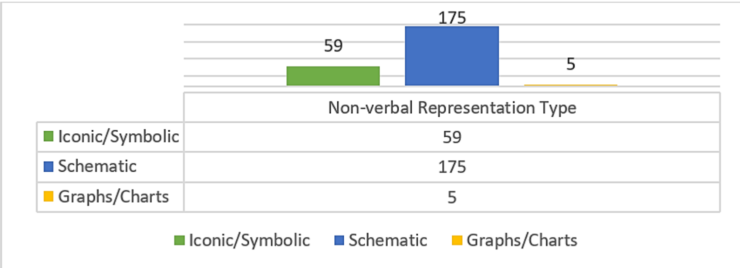


Table 3 shows the frequency of non-verbal representations deployed in all artifacts regarding the dimensionality ratio. After the analysis of each piece of information demonstrated by each verbal and non-verbal representation, it was concluded that whether a non-verbal representation repeats the information that existed in another representation (including verbal representations), demonstrates one piece of information that is not demonstrated by another representation in the texts, or demonstrates more than one piece of information, After obtaining this data, the dimensionality ratio for each representation is calculated. Data demonstrates that 23 non-verbal representations have a dimensionality ratio below 1. 123 representations have a dimensionality ratio that equals 1. Dimensionality ratio 93 of non-verbal representations is calculated as greater than 1. This means that these representations creatively demonstrated more than one piece of information. Semiotic resources in such kinds of representations are deployed in a way to demonstrate various information, such as the state of the moon and how it is seen by humans. These representations are generally included with metaphors such as the smiling sun. Exemplary cases for these representations are given in the next section.

Table 3

Dimensionality Ratios of the Non-Verbal Representations

Ratio	Frequency of Representations
1>	23
1=	123
1<	93
Average	1.07

Exemplary Cases for Student Designs

This part includes the analysis of exemplary cases. As stated earlier, student design after the teacher's instruction is a moment of resemiotization of content where students demonstrate what they learned in line with their interests and abilities. The exemplary artifacts are chosen in a way to demonstrate various cases regarding verbal representation relevancy, non-verbal representation types, and the dimensionality ratio of representations.

Figure 5

Exemplary Student Multimodal Science Artifact 1 and its Translation to English

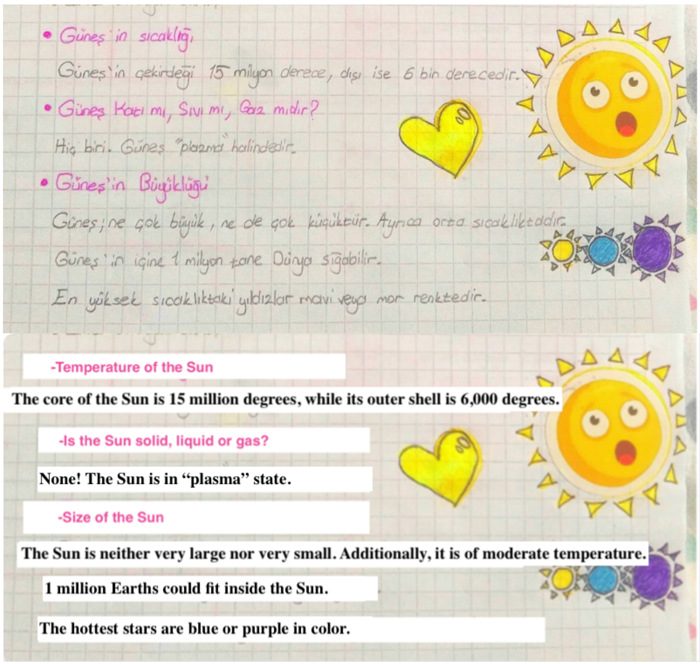


Figure 5 above shows an artifact that includes verbal and non-verbal representations to show information about the sun. The verbal representations include information about the temperature of the sun, the matter state of the sun, and the size of the sun. This text includes only schematic, non-verbal representations. The first non-verbal representation is the heart-shaped yellow metaphoric representation, which is unrelated to verbal information. This non-verbal representation can be seen as a decorative semiotic resource (Carney & Levin, 2002). The second non-verbal representation is a schematic representation that metaphorically depicts the shape and high temperature of the sun. By using a human emoji, it is depicted that the sun is quite hot. Since it provides information that does not exist in verbal representations, its dimensionality ratio is one. The last non-verbal representation gives information that compares the shape of the stars with their temperature. Again, since this representation repeats the information embedded in the last verbal representation, the dimensionality ratio of the artifact is below one.

Figure 6 is an exemplary case showing how the multimodal representational analysis chart is used to analyze the representational choices and dimensionality ratio (semiotic richness) of this artifact.

Figure 6

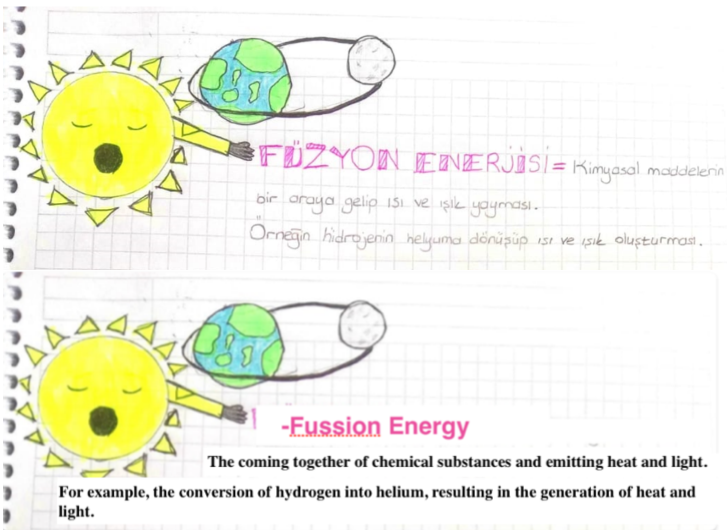
An Exemplary Measurement of the Semiotic Richness of an Artifact

Verbal Representations		Non-Verbal Representations						
5		*R(f)*	*Representation Type*			*Iconic/ Symbolic*	*Schematic*	*Graph/ Chart*
Related	*Non-Related*	5	1	2	3	5	-	-
5	0		X					
Number of Dimensions (D)				*Dimentionality Ratio (D/R)*				
6				6/5-1.2				

The artifact includes five verbal representations at the sentence level, and all of them are related to other representations. Five non-verbal representations are iconic or symbolic. The three celestial bodies demonstrate the Sun and other planets and how the Sun heats these plants. The bigger sun image demonstrates the bigger temperature and size of the sun. The heart icon demonstrates that "the Sun is good for us." The heart icon and three celestial bodies demonstrate one piece of information, and the bigger sun image shows two pieces of information. One piece of information is the size of the Sun, and the second is the amount of temperature. Therefore, the number of dimensions is 6. The dimensionality ratio is 1, and the information or knowledge is demonstrated through the creative design of the artifact.

Figure 7

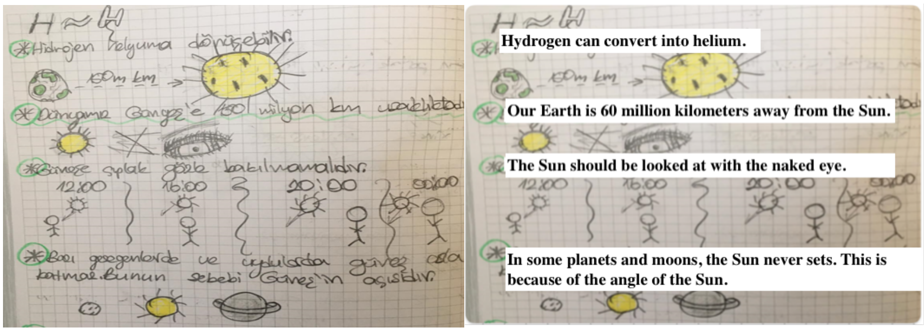
Exemplary Student Multimodal Science Artifact 2 and its Translation to English



The artifact in Figure 7 is designed in a creative way to demonstrate how the sun generates light. The verbal representations demonstrate how the fusion process takes place, and no information is given about the sun or the solar system. The non-verbal representation demonstrating the sun includes semiotic resources that show information in the following: First, the representation shows the shape of the sun and how it emits light through the arrowed tringles surrounding the shape. Second, the information shows the sun involves fusion processes for generating light and heat. This is achieved with a pointing metaphoric hand, which signs possess. The possession is also demonstrated by the emoji, which refers to presenting. Finally, information that shows the sun emits light and heat onto the earth and the moon circles the earth The yellow sun representation involves three pieces of information, so its dimensionality ratio is 3. The variety in the use of different representations is high. The representation including the earth and the moon demonstrates one piece of information that is not included by another representation, and, therefore, the dimensionality ratio is 1. Overall, the text provides information on how the sun generates light and heat by emitting light and heat onto the earth and the moon.

Figure 8

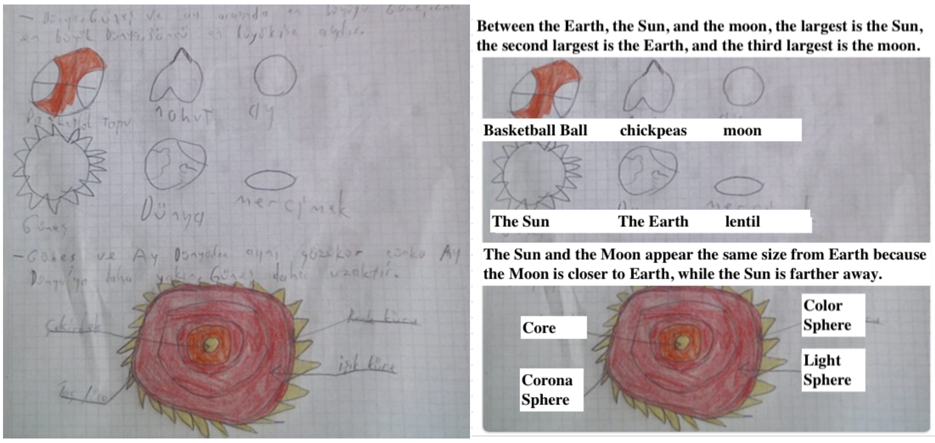
Exemplary Student Multimodal Science Artifact 3 and its Translation to English



The artifact in Figure 88 above involves verbal and non-verbal representations. The first verbal representation is related to the two icons positioned above. The verbal representation implies that “hydrogen can be transformed to helium." In the non-verbal representation, the hydrogen icon is related to the helium icon, which is demonstrated mistakenly but differentiated with boldness and related to the word in the verbal representation. These non-verbal representations are symbols and have a dimensionality ratio below one since they repeat the information of the verbal representations. The second verbal representation engages information about the distance of the earth from the sun. The accompanying non-verbal representation includes mathematical and schematic signs and repeats the information within the verbal representations. Therefore, the dimensionality ratio is below one. The third verbal representation involves the information that “humans should not directly look at or gaze at the sun." This information is repeated with a schematic representation above. Below the verbal representations, four sets of representations are designed, and these are demonstrated when a person can directly gaze at the sun. Without any verbal data, hours of the day are demonstrated, and the action of “a person can gaze at” is demonstrated through metaphoric human gestures involving rising and falling arm gestures. This information is given without verbal data. Humans are demonstrated through sticky icons and provide two pieces of information: “the gazing human” and “allowance for gazing." Therefore, these representations have a dimensionality ratio greater than one. The fourth verbal representation involves the information that “on some planets, there is no sunset due to the sun's positioning angle." Below this verbal data, the physical description is depicted through schematic representations. Since the non-verbal representation repeats the information, the dimensionality ratio is below one.

Figure 9

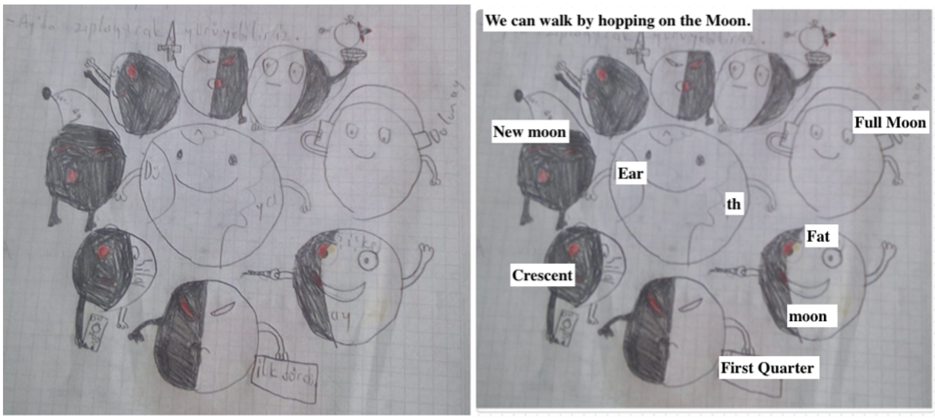
Exemplary Student Multimodal Science Artifact 4 and its Translation to English



The artifact in Figure 9 above involves verbal and non-verbal representations. Overall, the text gives information about the comparison of the sizes of the Sun, the Earth, and the Moon. In the first verbal information, it is given that the sun is larger than the Earth, and the Earth is larger than the Moon as well. To make this comparison more concrete, an analogy is made through schematic representations below the verbal representations. The sun is likened to a basketball ball, the earth is likened to chickpeas, and the moon is likened to a lentil seed. Since these representations provide new information about the sizes, their dimensionality ratio is equal to one. Next, verbal data provides information that the Sun and the Moon are both visible from the Sun since the Sun is quite bigger than the Earth and the Moon is quite closer to the earth. No non-verbal representation is related to this information. The last non-verbal representation is a schematic representation that depicts the structure and layers of the sun and is labeled with words. Its dimensionality ratio is greater than one since it gives information about the layers and their shapes.

Figure 10

Exemplary Student Multimodal Science Text 5 and its Translation to English



The artifact in Figure 1010 above includes non-verbal representations and labeling words. The text visualizes the states of the Moon through metaphoric schematic representations, including icons, in a humorous way. Being enlightened is demonstrated as a relaxing and good state. For example, the full moon is depicted as happy and relaxed, listening to music, while the full eclipse is depicted as angry and worried. The crescents are demonstrated in different emotions, and as they approach being fully eclipsed, they lose their comfort. This artifact creatively demonstrates the states of the Moon funnily and depicts this planetary process in a child's way of understanding and showing interest in the design choices.

Discussion and Conclusion

This study explored creativity in artifacts designed by gifted students in terms of representational choices within the social semiotics multimodal perspective. Creativity is seen as a core trait of gifted students (Kaufman & Sternberg, 2008), who are expected to yield creative learning products in the science classroom (Demetrikopoulos & Pecore, 2016). Some scholars (e.g., Besançon, 2013) remark that creativity in the classroom is viewed as doing something in a new way of doing science. This study embraced a similar view to Starko (2014, p. 25), who proposes that "at its most basic, creativity involves the generation of a new (idea, artwork, invention, etc.) that is appropriate in some context," and the context here is the science classroom involving discourse of science. What is more, the approach of the study is similar to Bock's (2016) in evaluating creativity in student-generated artifacts regarding the variety of representational choices. This study bridges two perspectives, which are social semiotic multimodality and the system approach to creativity, for exploring creativity in artifacts designed by gifted students. Results demonstrate that gifted students in this research have big potential for using various representations in various modes to demonstrate internalized representations as externalized learning products. The results first demonstrate that written language is not the dominant mode in the demonstration (or resemiotization) of scientific knowledge in artifacts. The use of schematic representations helps students visualize what resides in their minds and imaginations. In this regard, the non-representational choices help contextualize the demonstration of scientific knowledge. It was also observed that the symbolic signs generally stemmed from the discourse of science or the multimodal discourse of science. The mathematical mode and the innate symbols (Tang et al., 2011) are used to demonstrate the quantitative relationships taking place between entities or participants in information pieces. Therefore, if there is no quantitative relationship in the information piece, it is natural not to use graphs or charts in the artifacts.

Airey and Linder (2009) note that comprehension of the discourse of science and its language, which includes specific symbols, is a sign of being competent in that field. What is more, the depictions where scientific knowledge is adapted to daily life or real context can be seen as a sign of the re-contextualization of scientific knowledge. Further, it can be said that the collaborative deployment of symbolic and iconic representations enables students to demonstrate scientific knowledge more creatively. This can be considered an increase in the epistemic and aesthetic value of the representations in the artifacts. In this position, quantitative data yields that the representations designed by participants in this study are found to be sufficient to be evaluated as they demonstrate scientific knowledge through the creative deployment of representational choices. One more point is that, although one teacher instructed the same content, student designs have different features, including representational choices and the use of semiotic resources (i.e., color, shape, size, etc.). This finding is similar to that of Jewitt et al. (2001), who demonstrated that although a science teacher instructs students on the content with the same semiotic text structure and meaning-making resources for all students, students' designs or externalized learning products differed regarding the abovementioned representational features. In the context of this study, this situation can be attributed to the existing internalized structure of the content and the different creative potentials of the students who participated in the study. This situation is parallel to the proposition of Bock (2016), who states that multimodal design extends the space for creativity by enabling students to use various semiotic resources and modes for demonstrating their knowledge according to their interests.

In conclusion, artifacts designed by gifted students in the socio-cultural setting of a science classroom are the products of creative action, and their creativity is assessed regarding the multimodal discourse practices of the science classroom. The artifacts designed by gifted students were analyzed and it was observed that the variety and efficiency in the use of representations in different modes are high which is considered an indicator of creativity in the design of the artifacts.

Implications for Gifted Education

Learning products as artifacts are designed by choosing and deploying semiotic resources for meaning-making. In this respect, creativity can be explored by analyzing these resources pertinent to disciplinary discourse in the classroom. Moreover, other semiotic resources such as color, alignment, or syntagmatic choices in design can be analyzed within this approach for precisely analyzing the creative resources in student designs. The method of this study can be further extended to other student designs in different disciplines and other subjects in the science classroom. Moreover, the social semiotic multimodal perspective and multimodal pedagogy may explore other elements, or A's of creativity, in the socio-cultural setting of the gifted science classroom.

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Üstün Zekalı Öğrenciler Tarafından Tasarlanan Ürünlerde Yaratıcılığın Değerlendirilmesi: Sosyal Göstergebilimsel Çokmodlu Bir Bakış Açısı

Öz

Yaratıcılık, üstün zekalılığın temel bir özelliğidir ve bu nedenle yaratıcılığın değerlendirilmesi önemli bir yere sahiptir. Sosyo-kültürel bakış açısı yaratıcı ürünün ortaya çıktığı sosyal çevrenin tüm unsurlarını dikkate alır ve bu ürünün değerlendirilmesinde bu unsurları dikkate almanın gereğini vurgular. Üstün zekalı öğrencilerin sınıflarını sosyo-kültürel bir bağlam olarak ele alan bu çalışma, sınıfın çokmodlu söylem pratiklerini göz önünde bulundurarak üstün zekalı öğrenciler tarafından tasarlanan tasarımlardaki yaratıcılığın değerlendirilmesine sistemik bir yaklaşım getirmeyi amaçlamaktadır. Nitel betimsel bir yöntem kullanılmış ve on altı beşinci sınıf üstün zekalı öğrenci araştırmaya katılmıştır. Veriler, katılımcı tasarımları aracılığıyla toplanmış, çokmodlu ve göstergesel zenginlik analizi ile analiz edilmiştir. Sonuçlar, analiz edilen metinlerin çoğunlukla göstergesel açıdan zengin bulunduğunu ve değerlendirme aracının üstün zekalı öğrencilerin fen sınıfının söylem doğasına göre tasarımlardaki yaratıcılığı değerlendirmede etkili olduğunu göstermiştir.

Anahtar Kelimeler: çokmodlu tasarım, sosyal göstergebilim, tasarım, üstün zekalı öğrenciler, yaratıcılık