Exploring Representations of Student Time-Use

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Abstract. How does one visually represent the use of time? We explored students' use of graphical metaphors by asking undergraduates at a public French university to generate representations of their personal time-use including: activities, sequence, duration, timing, and frequency. The resulting use of space and form was analyzed by way of an iteratively developed coding scheme. We discuss how the analyses of the spontaneous productions support previous research on spatial representations of time, and the implications for the design of time management tools for students.

Keywords: Spontaneous representation · Diagrams · Visualization · Student time-use · Coding scheme · Visual content analysis

1 Introduction

How students utilize time has important implications for their academic and professional success [5]. Students need to effectively allocate time between competing priorities such as homework, sleep, and extracurriculars, with such decisions constituting important developmental steps toward adulthood.

There are five components that can be derived from time-use data: activities, duration (quantity of time on activities), sequence (order of activities), timing (start/end of activities), and frequency (number of occurences in an interval). The visual representation of these components offer numerous applications, from resource allocation, to event planning, to detecting patterns in human behavior. In education, the applications are particularly compelling, as pedagogical activities challenging students to think critically about time-use are a first step toward aligning time-use with strategic goals. They also present a substantial challenge, as temporal phenomena are not strictly visual and cannot be visually compared to their representations.

When representing time in language, we routinely employ metaphors [7], such as, "The deadline is sneaking up on me, but my manuscript is ahead of schedule!" We use metaphor and analogy to create correspondence between abstract and familiar concepts. Similarly, these mappings can be applied in visual forms: *graphical metaphors*, constructed to convey meaning. In this work, we explore students' use of graphical metaphors when representing time-use.

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1.1 Space and Time as Representational Media

The advantages of space for representation have been extensively documented [1,11] and the observation that space is best represented in a spatial medium is common place [8]. A variety of cultural artifacts, such as calendars and clocks, represent time in the medium of space. These are extrinsic representations, where the properties of the domain must be enforced on the medium in an arbitrary manner [11]. To represent sequence in a two-dimensional plane, some artificial device is required to enforce the property of linearity. This can be accomplished by a graphical form (e.g. an arrow) by a domain-specific representational format (e.g. a calendar), or by relying on reading direction as a convention for imposing linearity. A fundamental asymmetry is evident when using space to represent anything other than space and *a fortiori* time. This asymmetry is consistent with research in cognitive linguistics [2] which suggests that individuals use spatial information when thinking about time, but rarely use temporal information when thinking about space.

Just as we must choose between myriad linguistic metaphors, when constructing graphic metaphors the designer must make choices for how to use media to represent. Tversky [12] examines how space and form are used to convey meaning in diagrams. She first identifies the use of space for depicting order, positioning forms (marks on the page) along horizontal, vertical and central-peripheral planes. An examination of productions by children revealed a consistent relationship between writing direction and depiction of temporal sequence [13]. While space exists in multiple dimensions, form is constructed. Complex forms are constructed by combining simple forms in purposeful configurations. The simplest forms are points and lines, which can be extended, contoured and combined to generate realistic depictions of worldly objects, or more abstract flights of imaginative fancy.

1.2 Flexibility in Representation

In response to an instruction to produce representations, participants can do a number of things depending on the affordances of the medium and their "catalogue" of available responses. Reuchlin (as cited in [9]) coined the term *vicariance* for the ways in which an individual may rely on a number of redundant mechanisms for performing a cognitive task. We view representation as a vicariant process, where the potential representational formats are determined by the individual's repertoire of available behaviors. In the case of students (with paper and pencils) we might expect to see:

- Letters and numbers: labels, digits, etc. (descriptive)
- Figurative drawings: attempted realism (depictive)
- Standard representations: histograms, pie charts, maps, etc.
- Domain-specific representations: particular to a specific domain [4].
- Ad-hoc representations: inventing a new context-specific representational format rather than using an existing one.

If like Tversky [12] we consider the process of representation an indicator of underlying thought, then examining the graphic productions of student time-use may help us understand how students conceptualize this important factor of their academic success. Do students think of their time as linear or cyclical? Do they emphasize order or timing of activities? As a first step, we explore the variability of representational behavior in a student population. Our investigation is guided by two questions: (1) How do students use space and form to represent time-use? (2) Which mechanisms are used to represent each component: sequence, timing, duration and frequency?

2 Method

Twenty-five (22 female, 3 male) undergraduate Education majors (median age = 23) at a public French university participated as a course requirement.

2.1 Materials and Procedure

After a demographic survey, students were given one sheet of paper, a variety of pens and colored pencils, and one hour to complete the exercise. Instructions prompted students to represent their time-use for a typical week during the academic year. They were explicitly directed to represent activity (what), sequence (order), duration (quantity), timing (chronology), and frequency (number of occurrences), in as many representations as necessary, using any graphic conventions. Only the term representation was used, avoiding biasing formats with terms such as: chart, graph, sketch, text, etc.

2.2 Coding Scheme

The coding scheme was developed using a directed approach [6]. Starting with the categories of 'use of space' and 'use of form', coding variables were chosen in alignment with Tversky's [12] discussion of space and form. Operational definitions were developed for each variable with values that were exhaustive and mutually exclusive. The resulting scheme[1] was applied by three psychology graduate students who coded the entire sample. Coding results for the entire sample were evaluated for inter-rater reliability, with positive outcomes: use of space $\alpha = 0.87$, use of form $\alpha = 1.00$, and primary mechanisms $\alpha = 0.97$.

3 Results

3.1 Use of Space

The use of space in the diagrams (n = 25) was consistent with our expectations based on reading direction in French. Twenty-one diagrams were characterized

[1] A full description of the coding scheme can be found at https://osf.io/ms9kq/.

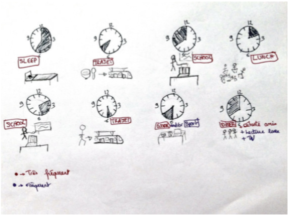

Fig. 1. Linear

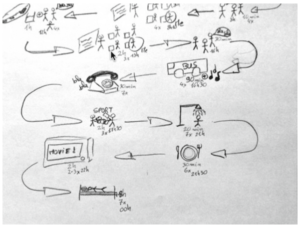

Fig. 2. Snake

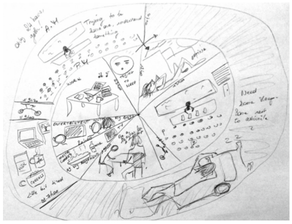

Fig. 3. Circular

as linear and four circular. Nearly all of the students (22) depicted the start of the day in the upper left corner of the page. Of the remaining three, two were circular representations placing the start of the day at the 12:00 position of a clock, and one was linear, starting in the lower left corner.

Nineteen of the 21 linear diagrams utilized both horizontal and vertical axes, while the remaining two used only the horizontal. Sixteen diagrams adopted a left-to-right orientation, while four alternated directions in a snake-like pattern. Figure 1 is a prototypical example of linear representation, with the origin in the top left corner. In these cases, the reader scans the diagram from left-to-right, jumping at the end of horizontal space, consistent with reading behavior. Four diagrams avoided the end of line scanning effect by alternating direction at the end of each line (Fig. 2). We dubbed these "snakes", as the information appeared to slither across the page. In each case a form, either line or arrow, accompanied the transition to indicate the change in direction. We contrast this with Fig. 1 in which the student assumes the viewer will skip to the next line and continue reading left-to-right, without the need to provide a formal indicator of direction. Of the four circular diagrams, three presented information in the clockwise direction (Fig. 3). There was minimal use of the radial orientation, with only two diagrams depicting flow from the periphery of the circles toward the center in a spiral fashion.

3.2 Use of Form

The use of form in the sample was varied, suggesting the scenario was effective in motivating students without biasing their choice of form. Raters found few instances of meaningful glyphs [12] such as dots, lines, and boxes. Arrows were the noticeable exception, found in 21 diagrams, employed to orient the viewer from earlier to later activities. Number was the most prevalent form, found in 23 of the 25 diagrams, followed by text (21). Nineteen included depictive drawings, while only 13 utilized more than one color. Figures 4, 5 and 6 exemplify the range of forms in the drawings from highly depictive (employing analogs) to highly descriptive (employing symbols). As evident in these examples, the use of descriptive vs. depictive drawings to describe activities fell on a continuum.

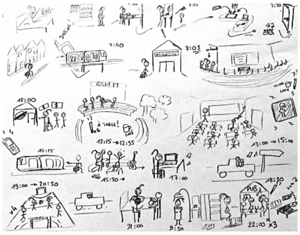

Fig. 4. Depictive

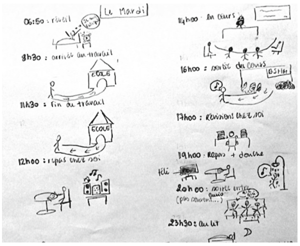

Fig. 5. Balanced

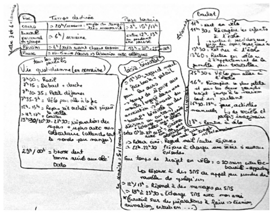

Fig. 6. Descriptive

There were no examples of prevalent but poorly executed drawings, suggesting that students utilized forms in accordance with their drawing ability.

3.3 Primary Mechanisms

Table 1 describes the percentage of diagrams that represented each component of time-use, as well as the number of diagrams utilizing each mechanism in the coding scheme. Only four individuals effectively represented all five components. Frequency was most commonly neglected, followed by duration, then timing. Sequence was always indicated by position, in many cases with the addition of arrows, while timing was almost exclusively represented by number. Two imaginative illustrations also utilized position to indicate timing by placing drawings around the corresponding positions of a clock face to indicate the time of day they began. Duration was often absent from the drawings, but when it was present, it was indicated by number. Two novel illustrations also utilized color to differentiate categories of activities.

Table 1. Frequency and methods of representing time-use components

Mechanism	Sequence	Timing	Duration	Frequency
% inclusion (n = 25)	100 %	96 %	54 %	46 %
Position	25	2	1	2
Size			4	
Text				
Number	2	21	9	6
Drawing		2	1	1
Arrow	15			
Color		2		2

4 Discussion

4.1 Student Productions

We found that in their use of space, students preferred linear patterns orientated with reading direction. Few students used circular patterns to indicate cyclical phenomena. Does this mean that students conceptualize their time as linear, rather than cylical? Tversky [12] made a similar observation, noting that students were reluctant to produce circular diagrams even when asked to model cycles and processes. She suggests that linear thinking is easier than cyclical, and students may prefer to consider a simple forward progression of time. Another explanation is the influence of cultural artifacts on the choice of representational format. The linear flow of information was evocative (though not strictly reflective) of calendars and agendas. Graphics conventionally used for planning may influence students' representational choices. In selecting form, students used both text and figurative drawings to represent activities, while number was used to describe timing, frequency and duration. Arrows were used exclusively to enforce linearity, directing the viewer's attention to the forward flow of time.

Of greatest interest were representational choices for the components of time-use. Although the instructions explicitly allowed for multiple representations, all students attempted to create a single integrated diagram. Alternatively, students could have created a series of representations for each component. Common formats such as charts and graphs were not exploited, despite their efficiency in communicating quantities (such as duration). It is possible that these formats were not familiar to the homogeneous sample of Education majors. In the future, we plan to sample students in science and engineering to explore variance in formats as a function of domain knowledge. The prevalance of depictions stands in contrast to the findings of Manalo and Useka [10], which suggest that students are reluctant to spontaneously produce diagrams given a communicative task. It is possible that the nature of the experimental task (representing activities with high personal involvement) as well as the imaginative nature of the instigating scenario may account for this discrepancy. It is possible that students are more comfortable constructing depictive representations of information that is personally relevant, as opposed to scientific phenomena. While no student constructed a complete domain-specific representation (e.g. diary, calendar), several utilized space in a fashion consistent with those conventions. The remaining productions demonstrated a preference for complex, integrated diagrams, reflecting an attempt at simultaneously inventing a representational format and expressing new content (ad-hoc context-specific representation). Alternatively, students might have placed a high value on informational efficiency. To examine this further, we suggest refining the stated goal from one of informing to differentiated tasks for planning, problem solving and exposition. While revealing sources of variation, a more strictly defined purpose might allow for more robust inferences about the underlying conceptual structure suggested by students graphic productions.

4.2 Implications and Future Work

Our analysis demonstrates conventional behavior in representations of time-use which can be applied to the production of organizational aids for students. Analysis of the pre-exercise survey showed, surprisingly, that few students consistently used paper or computer-based tools for planning and tracking time. Improving students' time allocation could help to improve performance and decrease failure rates in university [5]. Inspired by the preference for linear productions, it may be beneficial to design representations that draw attention to the cyclical nature of schedules, revealing the frequency of activities and supporting inferences about patterns of behavior. Rather than provide students with tools for planning and tracking, we suggest such tools be embedded in pedagogical activities on goal-setting. To maximize efficacy, the representations included should be consistent with students' conceptualizations of time-use (e.g. primarily linear, left-to-right), while simultaneously drawing attention to aspects of time-use neglected by students (e.g. the importance of sequence and frequency). As noted by Cox [3], individuals often perform better when utilizing self-generated external representations than those in formats invented by others. The exercise also prompted student reflection and discussion on time allocation as it pertains to prioritization and goal-setting. Preliminary analysis of the production content reveals diversity in the categorization of activities, which presents an additional question for research. We suggest that future work evaluate the content of productions by activity categories (school, homework, leisure, sleep, etc.) alongside pedagogical activities on time-use planning and evaluation. In the next phase of this research, we plan to repeat the diagramming exercise with students from different disciplines at an American University, utilizing digital pen systems to facilitate the content analysis. In addition to improving students meta-representational competency [4] we propose that constructing and analyzing representations of time-use may help students better understand how they allocate their time, and thus empower them to take control of this important factor of their academic success.

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