Measuring Student Autonomy Structures in a Montessori Classroom: Analysis of Patterns in Time and Configuration

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Abstract

A Montessori classroom was observed on ten different occasions when investigating autonomy structures. Each morning started with a Head Problems activity, followed by a three-hour Morning Work Period. The typical structure for Head Problems was a worksheet chosen by the teacher for all students to work on; the Morning Work Period was characterized by a wide variety of student-chosen works that guided student learning, with occasional individual feedback sessions with one of the teachers. Analysis of patterns in time and configuration (APT&C) quantifies qualitative patterns by measuring temporal and structural relations. During the Morning Work Period in which student autonomy was clearly supported, APT&C structural measures indicated more interdependence, complexity, and complete connectivity, and less centrality and active dependence.

SUMMARY

The Dilemma: Qualitative vs. Quantitative Methodologies

Research methods in education used for much of the 20th century were largely quantitative methods. Experimental and quasi-experimental designs were commonplace (e.g., Campbell & Stanley, 1966), and analytical techniques included ANOVA, regression analysis and their extensions (i.e., discriminate, factor, canonical and path analysis). The basic problem is that this general linear models approach seldom yielded findings that could be directly linked to educational practice. Within-group and within-person variance was often large, typically obfuscating differences between groups that could be attributed to so-
called treatments, practices or programs (Medley, 1977; 1979). Cronbach & Snow (1977) further extended ANOVA to deal with aptitude-treatment interactions (ATI), with hopes of reducing the within-group variance. But this, too, was seldom successful in yielding significant results.

In the 1970s and 80s, others began to explore alternative approaches that later became known as qualitative and case study methodology (cf. Guba & Lincoln, 1985; Stake, 1995; Yin, 2003). Qualitative methods have become widely used in educational research in the past two decades. One clear advantage of qualitative methods is that rich details of individual cases can give readers helpful insight into and understanding of the educational phenomena investigated. The unavoidable dilemma that often accompanies this approach is lack of justification for generalizability of findings. When samples are purposive and small, generalizability in the sense of making inferences from sample to population is seriously compromised. Indeed, respected books on qualitative methods avoid the term ‘generalizability’ and instead employ the notion of ‘transfer’ – i.e., results of what was found in this particular investigation may transfer to other similar situations the reader encounters (cf. Merriam, 1997).

Mixed methods approaches have become more popular in recent years (Creswell, 1998), in which both strengths of qualitative and quantitative approaches have been utilized. Well before this, an approach that quantified qualitative patterns had been proposed: APT.
**Measuring System Dynamics: APT**

Frick (1990) proposed an analytic-measurement procedure called Analysis of Patterns in Time (APT). This is a *paradigm shift in thinking* for quantitative methodologists steeped in the linear models tradition and the measurement theory it depends on (cf. Kuhn, 1962). The fundamental difference is that the *linear models approach relates independent measures through a mathematical function and treats deviation as error variance*, but APT measures a relation directly by counting occurrences of when a temporal pattern is true or false in observational data. Linear models relate the measures; APT measures the relation.

For example, in an observational study of mildly handicapped children in elementary school Frick (1990) found that, regardless of classroom context, when direct instruction was occurring these students were engaged on average about 97 percent of the time. In the absence of direct instruction, their engagement was about 57 percent. In other words, such students were 13 times more likely to be off-task during non-direct instruction. APT measures the temporal relation between direct instruction and student engagement.

**Measuring System Structure: APT&C**

Thompson (2006) provided the significant insight that APT could be extended to characterize *structure* or configuration of educational systems, in addition to characterizing system *dynamics* – or processes in education – as APT was designed originally to do. Frick and Thompson have since extended APT to measure and analyze configurations in education (APT&C, 2005).

Configural patterns characterize *structures* in education – i.e., how education is organized, or relations between parts. Axiomatic Theories of Intentional Systems (ATIS) provides the theoretical foundation for *quantitative* measures of system structure required by
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APT&C (Thompson, 2006). These measures include: complexity, hierarchical order, heterarchical order, compactness, centrality, flexibility, active dependence, passive dependence, independence, interdependence, strongness, unilateralness, weakness, wholeness, and vulnerability.

ATIS is a systems theory that predicts relationships among system properties, both structural and dynamic. There are over 200 axioms and theorems in ATIS. For example, #106 predicts: If system strongness increases, then toput increases. See Thompson (2006) and ATP&C (2005) for further details.

A co-author of the present study was engaged in research on student autonomy. She had a new insight. She realized that ATIS properties and APT&C would help the analysis of ethnographic classroom observational data she planned to collect. Measuring structural properties of systems is a way to characterize classroom structure that supports student autonomy.

**Student Autonomy Structures in a Montessori Classroom**

Autonomy or self-determination was defined by Deci, Vallerand, Pelletier & Ryan (1991) as a state where volition for action is totally internalized and determined by intrinsic motivation and not by external conditions. According to self-determination theory, intrinsic motivation cannot be fostered if autonomy support was lacking in social environments. Experimental studies and self-reported surveys conducted with school-age children found that perceived autonomy had a positive impact on perceived competence, intrinsic motivation and conceptual learning of school-age children (Grolnick & Ryan, 1987; Valas & Sovik, 1993; Hardre & Reeve, 2003).
The Montessori system aims to educate each child towards self-mastery and independence (Montessori, 1964). A distinguishing feature of Montessori classrooms is its provision for student autonomy. In a study comparing the social context of Montessori and traditional middle schools, Rathunde & Csikszentmihalyi (2005) found that Montessori students reported more support from teachers, more order in the classroom and spent more time with academic work rather than in passive listening.

The present case study explored how classroom structures support student autonomy in a Montessori classroom. Ten one-hour observations were conducted in April, 2006, in an upper elementary Montessori classroom located in southern Indiana. It had twenty-eight students, ages 10-12, a Montessori-certified head teacher and two assistant teachers.

Data on interactions between teachers, students and classroom resources were collected through ethnographic field-notes. The constant comparative method (Creswell, 1998) was used to identify common interaction patterns and classroom activity structures.

Measures of structural configurations were determined using definitions from ATIS. For example, one definition is:

\[ M: \text{Active dependent-component partition measure, } M_{AD}(S), = \text{a measure of initiating affect-relations.} \]

\[ M_{AD}(S) = \frac{1}{n} \left( \sum_{i=1}^{m} [\Pi d_i(v) + \log_2 |A_i|] \right) + n \times 100 \]

An investigator constructs a directed graph representing the affect relations in the system, consisting of vertices (v) and edges (e). The degree (d) of a vertex is the number of edges that touch it, and the degree of initiating edges is the number whose direction is leading from a vertex, (dI(v)). |A_i| is the cardinality of the set of components in the affect relation,
where $i$ indexes the different types of affect relations in the system. See reports for further technical details on structure measures and ATIS (APT&C, 2005).

We were interested in the structure of affect relations concerning ‘choice of work’ and ‘guidance of learning’.

Apparent from classroom observations and confirmed through teacher interviews, there were two clearly different activity structures in the mornings. Students normally started each day with a new *Head Problems* worksheet created by the teacher, consisting of math and logic-related problems. When this was completed (usually within an hour), they typically spent the next three hours in the *Morning Work Period*, during which students chose the type of *works* they wanted to engage in. *Works* constituted the major part of their learning goals: research projects related to physical science, natural science, history and geography; and book reports, science experiments and math workbooks that students needed to complete each nine-week period.

The *Morning Work Period* supported student autonomy with respect to which *works* they wanted to do, and whether they wanted to work on them individually or collaboratively. This morning activity pattern of initial *Head Problems* followed by the long *Morning Work Period* was consistent in all ten observations.

The data depicted in Figure 1 are from a typical configuration selected from one morning, since this configuration was relatively stable from one day to the next. While the specific *works* chosen by students tended to differ each time (as well as the daily worksheets for *Head Problems*), the activity structures with respect to the ‘choice’ and ‘guidance’ affect relations were highly similar (homeomorphic).
‘Centrality’ measures the number of indirect connections from each primary initiating component (i.e., one with a directed edge from that component which does not have a directed edge to it) to all others. During Head Problems, ‘centrality’ was found to be substantially higher since the teacher chose the same activity for all students to work on. In comparison, during the Morning Work Period the students chose various specific works they wanted to engage in (from literally hundreds of resources available) and who they wanted to work with. Correspondingly, ‘complexity’ (the number of connections between teachers, students and resources (works) in the classroom) was also higher during this time, since nearly every student was typically engaged with a different specific work (i.e., individualized instruction via engagement in that work).

‘Active dependence’ measures the number of emanating paths where connections were initiated, while ‘complete connectivity’ measures the structure where connections were both initiated and received. During Head Problems, ‘active dependence’ was higher since the teacher chose the head problems for all the students to work on. Without corresponding choice from students, ‘complete connectivity’ was non-existent. During the Morning Work Period, ‘complete connectivity’ characterized the structure regarding each student who selected the particular work which in turn guided their learning.

‘Interdependence’ was higher during the Morning Work Period as there were more instances of children choosing to work collaboratively with peers. Consequently, ‘independence’ was lower, as there were few instances of primary initiating components with respect to choice and guidance. Observations and interviews with teachers also indicated that free-flowing nature of the Morning Work Period enabled them to have one-to-one feedback sessions with students on report drafts written about their individual
works. These sessions could be as long as 45 minutes per student and gave teachers the opportunity to personalize instruction and correct errors.

The three teachers’ responses to the Problems in Schools Questionnaire (SDT Website, 2006a) showed all three of them to be ‘Highly Autonomy Supportive’. They valued encouragement, empathy and student viewpoints over the use of extrinsic rewards and punishment. This was evidenced by them encouraging students to be critical about the Head Problems. When there was missing or wrong information that might hinder problem solution, students were encouraged to provide suggestions and help contribute to the problem solution by researching for the required information.

Nevertheless, support for autonomy did not preclude the need for classroom management. Teachers were observed to be unhesitant to manage students when there were disciplinary problems or who were off-task during both the Morning Word Periods and Head Problems. This corresponded with Montessori’s philosophy that while student choice is respected, students who disrupt learning are stopped and redirected.

The structural configurations and teaching strategies were found to have a positive impact on the extent to which students felt intrinsically motivated to learn. Student responses to the Academic Self-Regulation Questionnaire (SDT Website, 2006b) indicated that they had a greater tendency to undertake learning activities because they perceived some personal value and identification with the learning goals, rather than because they felt compelled by external factors.

Discussion

Properties of structural configurations from ATIS and APT&C provide a common vocabulary that can be used to characterize and compare structure in educational systems.
In this study, the classroom was viewed as a system. The *Morning Work Period* epitomizes the structure of choice and guidance of learning with a wide range of learning activities in Montessori classrooms. This structure contrasts with the *Head Problems* structure, which is more typical of how learning is often organized in traditional K-12 classrooms, where the teacher has chosen the learning activity which most if not all students are expected to work on. It can be seen in Figure 1 that the property measures of affect relations for choice and guidance of learning indicate substantial differences in structure, even within this single case.

Through ATIS and APT&C we have new ways of conducting educational research in order to shed light on educational practices that result in the educational outcomes we seek. We used APT&C to quantify the structure in a Montessori classroom. Our study showed that relatively stable system structures of classroom activities are associated with student autonomy. Previous studies have shown that *perceived* autonomy supports intrinsic motivation and learning. This study shows what the classroom structure looks like that supports perceived autonomy.

**References**


**Figure 1.** Measures of structure of affect relations for ‘choice’ and ‘guidance of learning’