Generative instruction:  
Preliminary research with Singapore students

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ABSTRACT

This paper has three sections. Generative instruction and its origins are described in the first section. The second section comprises the results of school- and curriculum-wide implementations of generative instruction in Seattle and in Chicago. Finally, a preliminary study of aspects of the model with Singaporean students is outlined. Generative instruction is a dynamic, self-improving approach to teaching and learning. It incorporates built-in self-correcting procedures that shape the actions of teachers and students and improves the model as a whole. The carefully structured curriculum ranges from fluent knowledge and skills in basic facts and procedures through to intellectual skills such as generating focusing questions before reading a text, and hypothesis testing. Results from a ten year evaluation of the generative instruction model show that remedial students made two to three years progress for each year of instruction. Jobless adults advanced an average of 1.8 grades for every 20 hours of instruction and practice.

Students learn at different rates. Because of this, schools face the problem of what to do about those students whose progress is slow or negligible. This problem is usually conceived of as one of remedial instruction and it has vexed teachers and researchers for decades. While some approaches have shown initial promise, few have provided a coherent set of procedures that most teachers can learn to implement with a reasonable expectation of success. Most remedial instruction can be categorized as one of two approaches. One of these (the diagnostic-prescriptive approach) searches for explanations for failure that are intrinsic to the student. The other approach (the instructional approach) searches for problems with the instruction provided for the student. Some applications of the diagnostic-prescriptive approach rest on explanations such as intelligence, ethnicity or socio-economic status. Texts such as Herrnstein and Murray's Bell Curve (1994) illustrate how much this area has been driven as much by rhetoric as it is by research. Other diagnostic-prescriptive applications have seen researchers identify intrinsic characteristics of students that
correlate with learning deficits. Despite decades of research, many of the assessment strategies and teaching materials that have emanated from the diagnostic-prescriptive field have not yet proven to be effective (Colarusso, 1987).

Teachers using the instructional approach make the assumption that, while student factors influence learning, teachers have more influence over instruction. Teachers closely monitor student progress and adjust instruction according to their observations. A well-documented and successful example of this approach is Reading Recovery (e.g., Clay, 1993).

Walberg’s (1984) meta-analysis of approximately 3,000 studies supports the use of instructional approaches over diagnostic-prescriptive methods. The largest effect sizes (i.e., learning gains) were found in programmes that used reinforcement ($1.17^2$), cues and feedback ($0.97$), and science mastery learning ($0.81$). Diagnostic prescriptive methods had a lower effect size ($0.33$), as did passive factors such as teacher expectations ($0.28$), instructional time ($0.38$), computer assisted instruction ($0.24$) and class size ($0.09$).

Those factors with larger effect sizes are common to behavioural education. Early behavioural approaches to education such as Skinner’s (1968) programmed instruction and the personalized system of instruction (Sherman & Ruskin, 1978) produced impressive gains but teachers did not readily adopt them. More recently, direct instruction (Engelmann & Carnine, 1982) and precision teaching (Lindsley, 1990) have become influential. At the same time, behavioural educators have developed appropriate assessment tools (Howell & Morehead, 1987) and curriculum designs (Kameenui & Simmons, 1990; Tiemann & Markle, 1990). These instructional procedures stand out as being consistently superior to all other models in comparative evaluations (e.g., Gersten & Carnine, 1984). More recently, researchers and teachers have combined these strategies into an approach called generative instruction (Johnson & Layng, 1992).

**Generative instruction**

Generative instruction comprises the careful design, sequencing and presentation of learning experiences. It ensures that learning is acquired, retained, combined into complex repertoires, and applied in a variety of contexts. While most teaching ends when a skill is acquired and performed accurately, generative instructors consider this to be only the first of four stages which are illustrated in Figure 1.

**Figure 1. Morningside model of generative education.** (Source: Johnson & Layng, 1992)

Establishing. The teacher uses direct instruction to teach students
how to do something (e.g., solve an equation, write a sentence, explain a science concept). Students practise carefully and the teacher ensures that the unit of learning is established accurately.

Remembering. Students practise newly learned material at speed. They are expected to improve their performance until it reaches a stated number of correct responses per minute. For example, before moving to a more complex step in mathematics facts, students may be required to write 50 correct answers per minute for the current step. The fluency aim and student performance are recorded on a chart and students practise until they reach the aim. Students learn to manage their own programme, complete their own records and charts, and participate in instructional decisions based on the chart.

Enduring. Having achieved a fluency aim, students practise skills for longer periods and in cumulative reviews of other previously learned skills.

Applying. Students combine skills into complex repertoires and apply them in novel contexts. They generate their own discoveries. This is the origin of the term generative instruction.

An important characteristic of generative instruction is fluency. Training to accuracy without fluency produces less retention, endurance, and generativity. Highly fluent behavior is resistant to distraction, whereas non-fluent repertoires are easily distracted or interrupted (Johnson & Layng, 1992). Fluency in the components of compound or complex repertoires also enables novel composite repertoires to emerge.

Lindsley (1995) identified several products of fluency. Fluency increases the probability that students will retain what they have learned, perform for lengthy periods without error (enduring), apply their learning in novel settings, be more stable in their performance, understand what they have learned, be more confident, have more fun, be less likely to cheat and they will generate composite skills with little or no direct teaching of them.

The results of Generative Instruction

Generative instruction first appeared at Morningside Academy in Seattle in the early 1980s. Morningside Academy is a full-time school that provides programmes for students ranging in age from five to 18 years. Students diagnosed as learning disabled, who have never before gained more than half a year in any one academic year, typically make an annual gain of between two and three years in each academic skill (see Table 1).

Table 1
Mean annualized standardized achievement test grade level gains
Generative instruction has been successfully used with African-American male youths and adults enrolled in a job preparation programme. It has also been used with Asian-American women learning prerequisite mathematics, reading, spelling, or writing skills needed for office and computer-related skills training. Students in both groups made gains of one grade level for every 18-22 hours of class time per subject. This compares to 100 hours of class time per grade level typically provided in traditional education in the USA. Beginning in August 1996, Morningside introduced generative instruction to six inner-city Chicago public schools.

A preliminary study with Singaporean students

This preliminary study investigated one aspect of generative instruction: the effect of practice under timed conditions on the change in rate of performance. It emerged from a class exercise to teach students to chart the results of regular achievement probes.

Subjects and setting

The subjects were 78 Singapore university students enrolled in courses that included the assessment of students experiencing learning difficulties. All students spoke English and a "mother tongue" (Malay, Mandarin or Tamil). Sixty students were enrolled in certificate or diploma level continuing teacher education courses for special education teachers. Eighteen students were engaged in initial teacher training for regular education but were taking a special education option. Each course had one session each week for 12 weeks (40 students) or 13 weeks (38 students).
Procedures

Students were taught to use the standard celeration chart (Lindsley, 1990) in the first session of their course. The features covered included the ratio scale of the Y-axis, the calendar scale of the X-axis, recording of correct and incorrect responses, setting aims, drawing a split-middle trend line, and celeration (White & Haring, 1980).

From the second week of each course, sessions commenced with three one-minute probes as follows:

Reading-words. Students read an experimenter-selected passage as fast as they could in one minute. After a minute had elapsed they made a pencil mark beside the last word they read and prepared for the second probe.

Recalling-ideas. Students wrote down all the ideas that they could recall from the passage they had just read.

Charting-dots. The experimenter displayed a set of randomly generated numerals (one to nine), using an overhead projector. The numerals were grouped in fives with two spaces between each group to simulate a Monday to Friday data set with Saturday and Sunday treated as no-chance days. Students were instructed to treat the numerals as calendar-coordinated, rate-per-minute data and were required to chart them as dots on a single-cycle (1 - 10) ratio chart.

The experimenter began the probes by ensuring that each student had the passage, a blank paper, a chart, and a pencil. The experimenter held up a stop-watch, said, "Get ready," paused for three seconds, and then said, "Please begin" while starting the stop watch. Exactly 60 seconds later, the experimenter called "Stop!". There was usually a lapse of 30 to 60 seconds between probes.

When all three probes had been taken, students counted the number of words read, the number or words written when recalling ideas, and the number of dots correctly charted. To judge whether a dot had been correctly charted, students compared their probe sheet with a model displayed on the overhead projector. To be counted as correctly charted, a dot had to be in the correct place and linked by a line to the proceeding dot (except for Monday dots -- there was no line drawn from Friday to Monday). The experimenter checked that students had made accurate counts. The number of words read, words recalled and dots correctly charted were entered on a recording sheet and then this data was charted on a three-cycle (1 - 1000) ratio chart.

After three weeks of probes, students established a start mark for each probe by identifying the intersection between the mid-rate and mid-date of the three data points charted so far. Aims were established using the following procedure: For the reading-words and recalling-ideas probes, students drew a X1.25 per week celeration line from their start mark and drew the aim star at the point where it intersected a date line three weeks hence. The aim for charting-dots was arbitrarily established at 30 dots per minute five weeks hence. Probes continued to be administered at the beginning of each class session until the aim
dates were reached. Other course demands limited the number of probes possible to six reading-words and recalling-ideas probes and eight charting-dots probes.

Results

Each of the figures that follow show trend lines for the mean of all students (78) which were drawn using the linear regression trendline function of Microsoft Excel 5. The figures also show the data paths of four students. The students are the same in each figure and are identified using the same symbol across figures. The students were selected because their data paths illustrate particular points made below.

Figure 2 shows a trend line of the mean number of words read in one minute by all students. The trend of the mean rises from 185 words read per minute to 240 words per minute over five weeks. This trend would lead to the group mean rate of words read doubling in approximately 12 weeks. The performance of the four selected students was diverse. Student D was consistently slow to read and declined in rate over time. Although variable, students B and C all showed a trend towards faster reading. Student A’s performance was less variable and she almost doubled her reading rate over the six probes.

Figure 3 shows a trend line of the mean number of words written in one minute by all students when recalling ideas just read in the previous probe. The trend of the mean rises from 20 words written per minute to 30 words per minute over five weeks. This trend would lead to the initial rate doubling in approximately nine weeks. As in figure 2, student D shows a variable trend that a split-middle analysis reveals to be rising. Student A is moderately consistent but not improving. Students B and C also show variable performance but their trends are to increase.

Figure 4 shows a trend line of the mean number of dots correctly charted in one minute by all students. The trend of the mean rises from 11.5 dots charted per minute to 21.5 words per minute over eight weeks. This trend would lead to the initial rate doubling in approximately eight to nine weeks. Although student D performs at a lower than average rate, a trend to improve is evident. Student D’s performance appears as two parts of four weeks each. In both parts rapid progress was made but there was a step down between the fourth and fifth week. Student C showed no increase in rate while student B improved consistently at a slightly faster rate than average and student A increased the rate of dots charted at about the same rate as the class average.

Figure 2. Number of words read in one minute.

Figure 3. Number of words written in one minute from ideas recalled.
Figure 4. Number of dots charted correctly in one minute.

Discussion

While not all students made progress in each area that was probed, the class means for all areas improved over time. Initial performance improved by factors of 1.3 (reading-words), 1.5 (recalling ideas), and 1.9 (charting dots). This is a remarkable increase in rate considering the small amount of practice. The reading-words and recalling-ideas results were achieved with five minutes of practice under timed conditions after the initial probe. The charting-dots result was achieved after seven minutes of practice under timed conditions after the initial probe and some untimed practice of charting the weekly results of all three probes.

The figures illustrate several useful features of these charts: the probe-to-probe performance of the students varies. Some students' performance was lower some weeks than in the previous week while that of other students improved. The practice of making repeated measures and charting the results permits inspection of both the variability and the trend of the data.

Ratio charts predict future achievement by extrapolating the trend of the current data. In turn, this enables a teacher to judge whether a student's performance is matching an aim and to revise the teaching procedure or the achievement aim accordingly.

Ratio charts force teachers and researchers to attend to the rate of change. A student whose performance in reading improves from reading 30 words per minute to 60 words per minute has doubled her performance. This is a greater rate of change than that demonstrated by a student whose performance improves from 60 to 90 words per minute. Improvement is judged relative to a student's prior performance (student centred assessment) rather than according to an arbitrary curriculum standard (teacher or curriculum centred assessment.)

Before the first probes were administered, all the students were given explicit instruction in charting procedures and conventions. Usually this is the extent of traditional instruction. However, by providing a further seven minutes of timed practice along with a small amount of untimed practice in charting their data, these students almost doubled the rate at which they performed.

A fast reading rate can only be achieved if a student already has control over word recognition, syntax, semantics and phonetic decoding. A fast rate of writing recalled ideas indicates that the ideas have been read and recalled and that the student can find the words to express them. A fast rate of charting indicates that students can read and interpret data and can locate the appropriate point on a chart; this cannot be done if the student does not understand the features and functions of the chart. In short, performance at rate is an indicator of underlying understanding.
Rate of performance of basic components makes possible other desirable aspects of learning. Students who can perform basic skills at rate have a greater capacity to use those skills as components in problem-solving situations. There is evidence that students who learn to perform fluently also combine their learning and generate novel composite skills, learn more rapidly, retain what they have learned and are less prone to distraction.

References


2 Effect size.

3 A semi-logarithmic chart is used, permitting a straight line to represent an aim that increases over time according to a ratio. The aim line is sometimes called a "celeration line". A celeration line for a skill that is expected to double weekly is described as a X2 (times two) line.