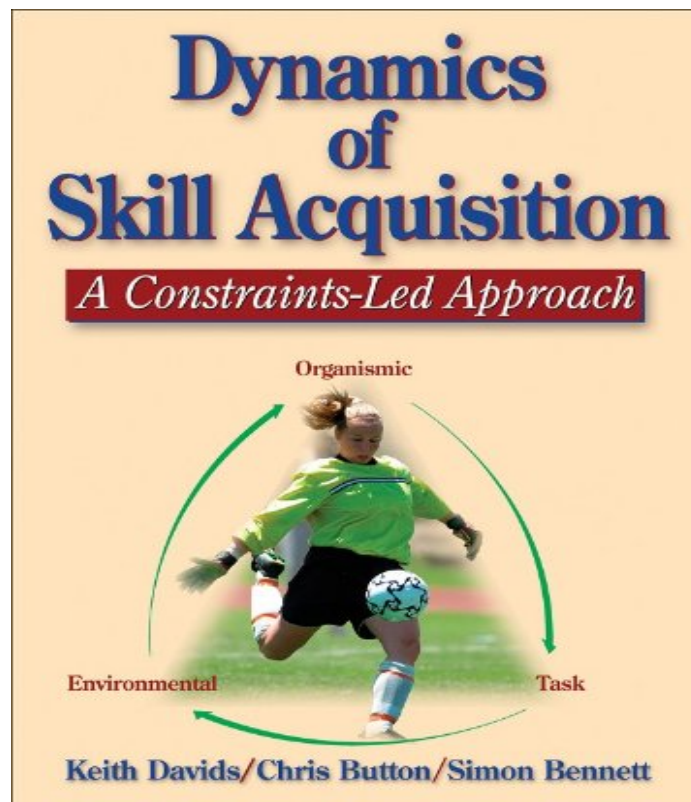


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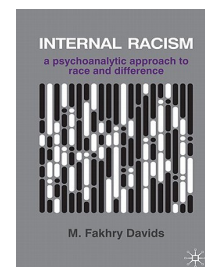
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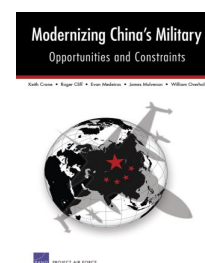
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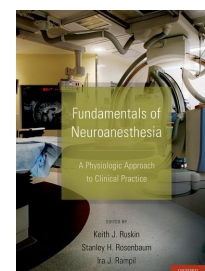
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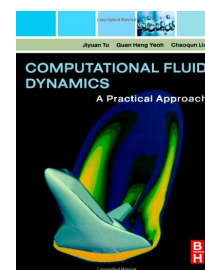
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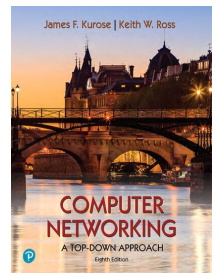
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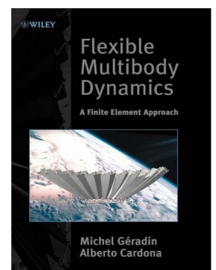
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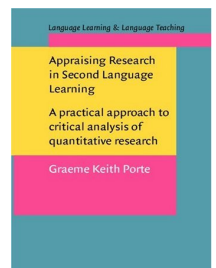
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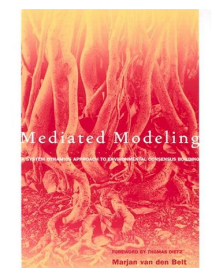
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Dynamics of Skill Acquisition

A Constraints-Led Approach



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Dynamics | of | Skill Acquisition

A CONSTRAINTS-LED APPROACH

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This book is dedicated to the ultimate self-organizing social system, my family: my wife, Anna, and my children, Mike, Jake, Charlie, and India

Keith Davids

For all the researchers past and present whose work has inspired the ideas developed in this book and unknowingly shaped our own academic pursuits

Chris Button

To the many individuals I have had the pleasure and fortune to work with, read of, and listen to, this book is a testament to your efforts and dedication

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PREFACE

Actions in daily activities such as sport and work differ in the nature of the demands they impose on performers. Some actions, like racket sports or driving on an expressway, are performed at high speeds, and others, like rugby, American football, martial arts, and physical therapy, may involve a significant amount of body contact. Many actions require a high degree of precision and accuracy of movement, such as playing golf or performing surgery, whereas others, like ballet dancing and ice-skating, emphasize the challenge of performing graceful, stylized sequences of aesthetic movement. Many activities pit us against the wild elements of nature when hiking, mountaineering, kayaking, or skiing. Despite the huge variety of constraints imposed by various sports and daily activities, one thing they all share is a requirement for performers to coordinate and control movements effectively.

Movement practitioners in various physical activities understand that skilled learners are able to

- produce functional, efficient, and effective movement patterns that appear smooth and effortless;
- typically demonstrate precise timing between their movements and ongoing environmental events;
- consistently reproduce patterns of coordinated movement, even under severe time constraints or competitive pressures;
- perform movements that are not automated in the sense of being identical from one performance to the next, but are subtly varied and precisely adapted to immediate changes in the environment; and
- integrate different limb movements into an aesthetically pleasing pattern when necessary.

Purpose of the Book

Humans operate in information-rich, dynamic environments and require complex coordination patterns to interact with important surfaces, objects, and events. An important challenge for movement scientists is to understand how coordination patterns are assembled, controlled, and acquired. In recent years there has been an increasing interest in the constraints that shape and influence the acquisition of movement skills. Our purpose in this book is to synthesize and elucidate a constraints-led approach to skill acquisition.

The study of human movement now bridges many related disciplines, including motor development, motor control, psychology, biology, motor impairments,

and physical therapy. Although we attempt to apply our discussion of movement as broadly as possible throughout this book, we will often use movement models from sport, exercise, and physical activities as examples to describe key ideas. As sport enthusiasts ourselves, we recognize that movement models from sport can provide particularly rich task constraints in which to study and understand important aspects of movement behavior (Davids, Button, Araújo, Renshaw, & Hristovski, 2006). One of the main objectives of physical educators, sport scientists, movement scientists, psychologists, and physiotherapists is to develop valid conceptual models of human movement behavior that is based on research (Post, Pijpers, Bosch, & Boschker, 1998). The development of a comprehensive model of motor control is necessary before one can consider issues related to learning, but this in itself is not a simple task because “the story of even a simple movement will have intentional, mechanical, informational, neural and muscular chapters” (Michaels, 1998, p. 65). It is becoming clear that a rigorous model of human movement requires a multidisciplinary framework to capture the different interlocking scales of analysis (e.g., neural, behavioral, psychological) and the many different subsystems (e.g., perceptual and movement) involved in producing behavior.

From a practical perspective, understanding how coordination and control is achieved promotes an informed organization of learning and rehabilitation environments and more effective use of practice and therapy time (Davids & Handford, 1994). Studying these processes in human movement systems is vital for considering issues involved in

- ergonomic equipment design;
- organizing and structuring coaching, teaching, and training tasks;
- planning and managing exercise prescription, therapeutic, and rehabilitation programs;
- preventing injury and associated health and safety considerations;
- understanding the nature of individual differences at various levels of performance;
- understanding how to transmit information to learners and patients in rehabilitation;
- getting a feel for children’s movement capabilities at various stages of development; and
- interpreting movement disabilities and disorders and their effects on perceptual-motor function.

A conceptual model of coordination and control is not just important for designing learning environments, it is also important for ensuring that learners have positive experiences when acquiring motor skills. Given the alarm expressed at the lack of physical activity and poor movement competency

shown in affluent societies (Our Healthy Nation Report, UK Government, 1999; World Health Organization report, 2002; Healthy Eating Healthy Action, New Zealand Ministry of Health Report, 2003), this type of knowledge is vital for the design of physical activity programs to provide the basic skills necessary for subelite sport and exercise participation (see also Clark, 1995). The goal of this book is to outline a reliable and comprehensive model of human movement to provide a valid framework (i.e., concepts, methodological tools, and language) through which students and practitioners can understand and address these issues.

Organization

This book is divided in two parts to facilitate understanding of theoretical and practical concepts. In part I, we describe the theoretical basis of a constraints-led learner model that has emerged within the literature on motor learning. Part II provides several practical implications of the constraints-led approach. We will discuss the relationship between the theoretical concepts introduced in part I and the practical concerns facing the learner and movement practitioner. In part II, we will attempt to bring the constraints-led model to life, especially in chapter 10, where a number of case studies are highlighted.

Audience

This book is written for people with an interest in movement coordination and control and skill acquisition. This includes movement scientists, sport scientists, psychologists, biomechanists, physiologists, coaches, teachers, physical educators, and physical therapists. Advanced undergraduates with a firm grounding in the traditional theories of motor behavior, beginning postgraduates, and academic faculty will all benefit from an understanding of ecological constraints on movement behavior.

The book contains an introduction to many key theoretical ideas that will enhance practical applications. For this purpose, we use examples throughout and case studies in chapter 10 to show how theoretical advances in the natural sciences can help our understanding of the acquisition of movement coordination. Spotlight on Research sidebars and additional readings are presented in each chapter to help readers understand how interacting constraints shape movement behavior. Readers are encouraged to use these features to enhance their learning experience.

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I

PART

Introduction to Skill Acquisition Theory and the Constraints-Led Approach

Part I provides an overview of the key theoretical contributions to the study of skill acquisition and introduces the constraints-led approach.

Chapter 1 reviews the contribution of traditional theories to the study of skill acquisition, including the information-processing approach. In this chapter, we discuss important practical considerations such as practice organization and feedback delivery to provide a basis for comparison in later chapters. In chapters 2 and 3, we explore the relevance to motor performance of some alternative theoretical insights, particularly those offered by Russian physiologist Nikolai Bernstein (1967) and American psychologist James Gibson (1979). By emphasizing the need to adopt a systems perspective on human behavior, their theoretical contributions have had a major

impact on our understanding of movement coordination and control. Their insights have encouraged researchers to model the performer as a complex movement system composed of many interacting subsystems. These ideas have focused attention on how coordination emerges between the parts of each person's movement system, as well as the key variables or constraints that the person uses to regulate or guide these coordination patterns.

Clearly, constraints play an important role in shaping the ways in which humans can move to effect change in their environment. In particular, chapter 2 focuses on the physical constraints affecting the performer by discussing key concepts of dynamical systems theory, and chapter 3 describes ecological psychology as a suitable framework for understanding informational constraints on behavior. In chapter 4, we present an overview of the constraints-led approach to skill acquisition, which forms the foundation of part II. Although there are a number of models of constraints, in part I we focus on the implications of Newell's (1986) model as a template for understanding how motor skills are acquired.

Traditional Theories of Skill Acquisition

CHAPTER OUTLINE

Skill Acquisition: Definition and Theories

- Association Theories
- Neuromaturational Theories
- Fitts' Stage Theory of Motor Learning
- Information-Processing Theories
- Neurocomputational Theories

Common Features of Traditional Theories

- Representations of the World and Movements
- Learner as Hierarchical Control System
- Capacity-Limited Storage
- Indirect Perception
- Reduction of Error and Noise
- Models of Limited Range of Movement

Implications for Movement Practitioners

- Amount of Practice
- Practice Variability
- Practice Organization
- Part-Task Practice
- Instructions and Feedback
- Demonstrations of Technique

Summary

Over the last century, the question of how humans learn to control and coordinate their movements has received much attention, with scientists proposing many different theories. Although there is still considerable debate over which theory is most appropriate (Summers, 2004), the importance of developing a strong theoretical framework for studying skill acquisition and guiding practical activity remains clear. Many practitioners use models of human behavior, either implicitly or explicitly, to plan their decision making for focused, effective practical activity. Theories of skill acquisition can help practitioners develop an appropriate model of the motor learning process that is necessary for understanding how learners acquire motor skills. How do you currently view motor behavior and how does your understanding underpin the way you teach or coach? As part II of this book will show, this knowledge provides a philosophy for structuring practice contexts, providing information to learners, using visual demonstrations, and other important tasks.

This chapter provides a brief historical overview of the traditional theories of movement skill acquisition. This overview will enable us to compile a number of implications for movement practitioners. Summarizing the general features of traditional theories will help us compare them with alternative theories described in subsequent chapters. As you read this chapter, we encourage you to keep an open but critical mind regarding the strengths and weaknesses of the different theories discussed. (For more detailed overviews of these theories, refer to Schmidt and Wrisberg [2004], Magill [2006], and Haywood and Getchell [2005]). Let's start by considering what we mean by the term *skill acquisition*.

Skill Acquisition: Definition and Theories

Motor skill acquisition has traditionally been described as the internal processes that bring about relatively permanent changes in the learner's movement capabilities (Schmidt & Wrisberg, 2004). For example, movement skills such as riding a bicycle, catching a ball, or driving a car require a good deal of practice to allow us to perform them effectively. **Skill acquisition** requires us to interact effectively with our environment, detect important information, and time our responses appropriately. It should result in coordination patterns that are adaptable to a range of varying performance characteristics. Adaptive behavior is important because conditions like the environment, task requirements, and our motivations can change every time we perform a motor skill (Davids, Bennett, & Newell, 2006).

The process of skill acquisition is distinct from execution of the skill (motor control) in that learning is a gradual process that occurs over many performance attempts, resulting in behavior that is less vulnerable to transitory factors such as fatigue, audience effects, and anxiety. One way researchers have tried to understand skill acquisition is by examining performance changes over time. For example, in early research efforts, Bryan and Harter (1897) studied

how learners' typing skills developed while practicing to send and translate Morse code. Over a period of 40 weeks, the telegraphers went through distinct phases of improvement and periods where performance levels plateaued. The inference from such performance curves was that learners initially construct simple elements of the skill, interspersed with periods of consolidation (i.e., development of automaticity), before linking individual parts of movements (in this case, individual finger presses) into more integrated patterns of behavior (linked sequences of finger presses typed as words).

Snoddy (1926) proposed that learning can be described in a predictable manner using a mathematical equation ($\log C = \log B + n \log x$, where C is a measure of performance, x is the amount of practice, and B and n are constants). This **power law of practice** predicts a straight-line relationship between the logarithmic functions of practice time and performance (see figure 1.1). The power law of practice simply states that performance improves with practice, although there are eventual physical limits to this relationship.



Practicing a skill such as riding a bicycle leads to performance improvement. Skill acquisition helps us to interact effectively with our environment, detect important information, and time our responses appropriately.



Figure 1.1 The power law of practice predicts a straight-line relationship between the logarithmic functions of practice time and performance.

Despite being researched for some years, the power law of practice has failed to gain universal acceptance because it has become clear that learning is often characterized by sudden jumps, rapid improvements, and even decrements in performance over time. For example, although Crossman's (1959) classic study of cigar makers seemed to support Snoddy's power law, researchers continue to question the generality of this prediction because many types of learning curves have been observed in motor learning experiments as well as practice (see Newell, Liu, & Mayer-Kress, 2001).

Initially, researchers favored a much broader definition of skill acquisition that included movement activities with a heavy emphasis on cognition, such as playing chess or learning new languages (e.g., Bryan & Harter, 1897; Chase & Simon, 1973; Ebbinghaus, 1964). Indeed, research examining such skills has contributed significantly to our understanding of processes such as expertise, attention, and automaticity of movement control. More recently, there has been a tendency to examine the acquisition of movement coordination and control with an equal theoretical emphasis on cognition, perception, and action. Before we discuss this more recent trend in later chapters, we will briefly describe five traditional theoretical approaches to skill acquisition: association theories, neuromaturational theories, Fitts' stage theory of motor learning, information-processing theories, and neurocomputational theories.

Association Theories

Early contributors to the study of skill acquisition were interested in the relationship between movement stimuli (information) and action (e.g., Skinner, 1938; Thorndike, 1927; Woodworth, 1899). In examining this association, researchers employed either relatively simple repetitive movements or reflexes to test their assumptions. For example, to examine the roles of memory and feedback during learning, Woodworth (1899) required blindfolded participants to draw lines of varying lengths. This research demonstrated that repetition of the movement without feedback did not improve accuracy during practice. However, when researchers provided simple right or wrong statements after each trial, participants' accuracy dramatically improved. These findings indicated the important role that feedback plays in reinforcing learning.

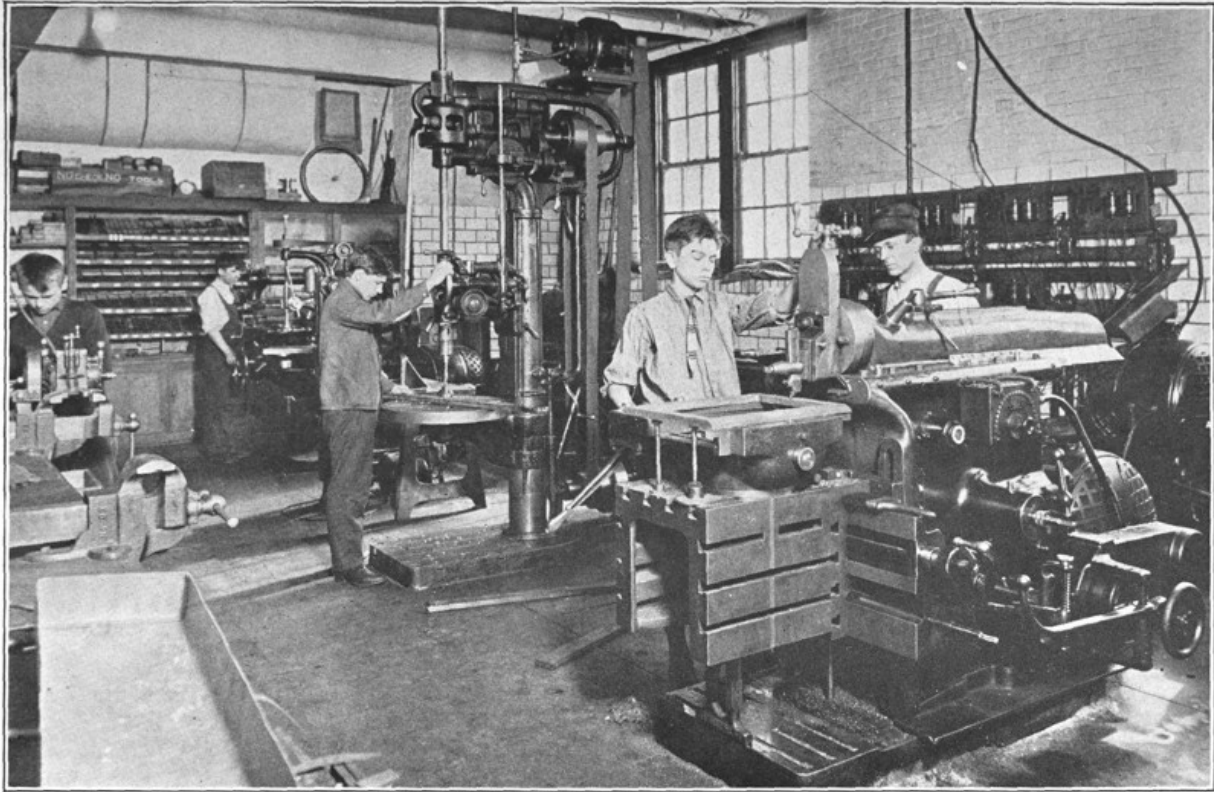
Other early researchers on skill acquisition believed that reflexes were the basic building blocks of movement and that people were passive recipients of external sensory inputs that drove their behavior. For example, to study movement in isolation of inputs from higher cortical brain regions, Sherrington (1906) conducted experiments on animals whose spinal cords had been surgically cut in order to study the circuitry of the central nervous system (CNS). Prominent experimental psychologists such as Skinner (1938) and Thorndike (1927) were also influential during this period. However, many researchers criticized these methods for assuming that animal models were relevant for studying motor skill acquisition in humans. Further, the research tended to focus too much on observable performance outcomes rather than understanding of the underlying processes of skill acquisition. In addition,

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are employed by him in the dual capacity of manual-training and industrial teachers and of regular workmen engaged in repair and construction. Each building has a head manual-training teacher, who supervises the work of the industrial classes, of the part-time classes, and acts as vocational adviser for the school's pupils. Gymnasium and swimming-pool attendants are employed by the head teachers of the physical education departments.

The departmental teachers in the head building (Emerson School) act as assistant supervisors of instruction in their subjects and have general oversight of the courses in their subjects as taught in the other buildings.

Departmental teaching is carried out in the Gary schools to an extent generally unrealized in other public schools. It is considered that, with the exception of the lowest grades, no arguments which apply to the institution of departmental teaching in the high school are inapplicable to the grades of the common school. The special activities undoubtedly call for specialists to conduct them. History, language, literature, mathematics can also be much better taught if the teacher can devote his or her attention to the particular methods and orientation of the respective subjects, and not be required to be equally at home in the technique of all of them. Teachers can rarely be found who are many-sided enough to teach well even all the common branches, without the special activities. The Gary schools, therefore, adopt for all, except the first two or three grades, what are practically advanced high-school or college methods of specialized teaching.



THE MACHINE-SHOP AT THE EMERSON SCHOOL

In these lowest grades all the regular subjects are taught by the one grade teacher; in the other grades practically all the subjects are departmentalized. A unit school plant which should have fifty-six classes, divided proportionately among the grades, in addition to the nurseries and kindergartens and special classes, would employ for grades 1 to 3, *sixteen* teachers, as follows: For English, mathematics, 8; for manual training, 2; for nature-study, 2; for music, 1; for expression, 1; for physical training, 2.

For grades 4 to 12, *forty-six* teachers would be employed: For English, 4; for mathematics, 2; for Latin, 1; for German, 1; for French, 1; for Spanish, 1; for history, 1; for fourth-and fifth-grade English, mathematics, history, and geography (either departmentalized or undepartmentalized), 8; for chemistry, 2; for botany, 2; for physics, 2; for zoölogy, 2; for freehand drawing, 2; for architectural drawing, 2; for mechanical drawing, 1; for music, 2; for expression, 2; for cooking, 1; for sewing, 1; for manual training (not

including the industrial shops), 2; for physical training, 6. Four teachers would be employed in the kindergarten department. A unit plant of this size would require one executive building principal, and one supervisor of instruction. Two school nurses and a school physician would also be employed.

Such a distribution of the teaching force would be considered the ideal for a unit school plant of all grades, accommodating between fourteen hundred and twenty-two hundred and fifty children in two duplicate schools. It will be observed that this most careful specialization of teaching does not increase the number of teachers required. At least fifty-six teachers, with a number of special teachers, would be required in any school of fifty-six classes, run on an undepartmentalized plan. The Gary plan, therefore, without increasing the number of teachers, provides for a much higher expertness of service. Indeed, Superintendent Wirt has worked out a form by which a school of thirty-two classes would only require thirty-two teachers, including the special teachers, and with most of the work departmentalized.

Programs may be arranged for schools with any number of classes. The number of classrooms and teachers required will be approximately as follows, including supervisors, special teachers, librarians and playground instructors:—

A 12-class school requires 8 classrooms and 12 teachers.

A 24-class school requires 15 classrooms and 23 teachers.

A 36-class school requires 22 classrooms and 33 teachers.

A 48-class school requires 29 classrooms and 43 teachers.

A 60-class school requires 36 classrooms and 54 teachers.

A 72-class school requires 43 classrooms and 64 teachers.

In the 72-class school, 43 classrooms and 54 teachers are required, in addition to the provision for auditorium, playrooms, and library. For this work 10 teachers are required, making a total of only 64 teachers for 72 classes. The traditional elementary school requires 72 teachers and 72 classrooms for 72 classes; the manual-training shops and the manual-training teachers are extra. In addition

there would be librarians in branch public libraries, playground directors in public playgrounds, and special teachers as supervisors of music, drawing, physical training, manual training, and nature-study. Often in the traditional school 80 or more persons are employed for the instruction of 72 classes, not including the building principal and assistants.

An important feature of the teacher organization in the Gary school is the division into senior and junior teachers, or head teacher and assistant teacher. Since each classroom accommodates two teachers according to the duplicate-school plan, the teacher who has been longer in service is designated as head teacher. The less experienced teacher acts under her direction. The head teachers, for instance, in the "X" school may visit and criticize the work of the assistant teachers in the "Y" school during the last hour of the day when the "X" school is not in session. Similarly the junior teacher in the "Y" school may visit the work of the "X" school during the first hour. Inexperienced or weak teachers may thus be developed under the direction of the more experienced. New teachers are thus being constantly trained in the new régime and spirit of the Gary school. The school is thus made an extension of the normal or training-school for teachers. The teachers continue to learn as well as the pupils. The question how teachers are to be procured for the new demands which the Gary plan puts upon them is thus answered. The school itself trains the teachers.

The responsibilities of the teachers for the auditorium period have been discussed. Under the old Gary plan each auditorium period was in charge of one teacher who acted as assistant principal. The teachers alternated in organizing the dramatic and other features of the auditorium work. Recently Superintendent Wirt has decided that this auditorium work functions better if it is specialized. In the new 72-school program, four teachers give their time exclusively to the auditorium exercises. One teacher has charge of the music; one has charge of the art, literature, history, civics, and current events; one has charge of the presentation of material relating to the science work; and one has charge of the presentation of the material relating to the shops and industries. In a properly equipped auditorium, with

stereopticon lantern, motion-picture machine, stage, player-piano, organ, and phonograph, the auditorium teachers can do many things better with large numbers of children than the regular teachers can do with small numbers. The regular classroom teachers are expected to coöperate in this frequent presentation of work by their classes in the auditorium in order to use it as a place for “application” work and for motivating the academic work of the school.

In the new program, the “application” work is also specialized. Experience has shown that some teachers have a special talent for this imaginative and constructive side of teaching, and prefer to devote their entire time to it. In this scheme, the “application” teachers have six classes daily out of a total of twelve classes in each of their respective groups. They are thus able to meet each of the twelve classes of their respective groups every other day, week, month, or term. Or these teachers may select from each of the groups of three classes the pupils who need special work in language and mathematics, and meet these pupils every day. For the average pupil all of the opportunity necessary to make an application of his language and mathematics is provided in the regular manual-training, drawing, music, and expression classes. The “application” teachers meet their respective classes in the manual-training, drawing, music, and expression rooms. The facilities of these special rooms are used for “application” purposes. The “application” teachers are expected to make suggestions to the special teachers of these subjects concerning the opportunities to teach language and mathematics through the “application” opportunities of the regular work of their respective subjects. Each “application” teacher may be constituted the head of a group of eight teachers. The “application” teacher is the correlating agent for all the work of the twelve classes; also she works with all of the twelve classes as a constructive examiner, and is constantly placing before the children real problems of the type that the world of industry, business, and citizenship will place before them when they leave school. She may not be able to present these problems as well as the world will present them later, but the immediate and daily reaction while the child is in school should be invaluable in preparing

him for meeting the more difficult problems which arise when he has completed his school course.

Class periods may be 40 or 50 or 55 minutes instead of 60. Teachers have six hours in school with 60-minute periods, five and one-half with 55-minute periods, and five hours with 50-minute periods. Pupils have a school day of seven, six and one-half, and six hours respectively, in addition to an hour for luncheon. The playground teachers are on duty an additional hour. Each teacher has an hour a day free for her own work. When her day is finished, she is supposed to leave the building. It is expected that all paper work, as well as all the work of the children, will be done in school. The purpose is to make the teacher's day only six hours, without the burden of extra time at home.

An interesting extension of this teacher-organization plan is the new training course for outside teachers or principals who are desirous of studying the Gary school plan and teaching methods. Visiting teachers and principals are allowed, at a fee, to attach themselves as assistants to teachers or principals, and follow the work through a course of weeks or months, in exactly the same way that the small child acts as "helper" or "observer" to the older child in the laboratory or shop or the junior to the senior teacher. The fee goes to the teacher or principal who instructs the visitor. This novel way of teaching the principles of the Gary school, not by lectures, but by direct practical assistance on the part of the visitor, is typical of that insistence upon "learning by doing" which is the keynote of the Gary instruction.

The Gary plan acts on the theory that the good teachers should be given initiative and responsibility, while the inexperienced and weak teachers should be trained into initiative and responsibility. The usual plan in school systems is to make the experienced and inexperienced, strong and weak, coördinate with one another, and all subordinate to the supervisor or superintendent. The Gary plan thus secures the utmost from the good teachers, and trains the poor ones.

Instead of employing special “visiting teachers,” as is done in many school systems, the teacher in the Gary school is given the responsibilities of the “visiting teacher” by being made a “register teacher” for a subdivision of the school district. In this way cases of maladjustment to school, home, or neighborhood conditions may be met. The school population of the city is geographically districted in such a way that each district holds about fifty families. The children in a district are assigned, irrespective of age or grade, to one of the grade teachers. Each “register teacher” meets her group once a week for general conference. She gives out the monthly reports. Failure in self-control, irregular attendance, tardiness, and other matters are reported to her. No child is excused from class without her permission, and she is expected to call at the homes of the children when necessary or to meet their parents at the school. Each “register teacher” holds the same children from class to class as long as they live in the district. She corresponds almost exactly to what is known as the “faculty adviser” of the college student, a guide and friend for the general conduct of school life and for difficulties that arise. The “register teacher” is a sort of disciplinary and sociological overseer for a group of children living in the same neighborhood. She has a set of blanks which in fact provide a basis for a complete sociological survey of her district. These she is supposed to fill in, as facts about living conditions, etc., come to her attention. It seems evident that this work, while exacting, involves no more than a teacher should know. No more valuable sociological training could be imagined for the intelligent and progressive teacher. Such work relates her at once to the general community life, and makes her profession of a far more serious importance than is usually given to the grade teachers in the public schools. This work is typical of the demands for a new initiative and intelligence that the Gary plan makes upon the teachers, and also of the immense educative value of these demands.

The effort is constantly made in the Gary schools to bridge the gap between teacher and pupil. An important recent innovation is the institution of “teachers’ assistants.” Students in the sixth, seventh, and eighth grades have ten weeks for drawing, ten weeks for science, ten weeks for shopwork, and ten weeks for service as

“teachers’ assistants.” The students act as laboratory and studio assistants only in the departments in which they have a special interest. Three or four students assist the science teachers, three or four the drawing teachers, and three or four the shop teachers. Playground teachers, auditorium teachers, music teachers, etc., have as assistants the students especially interested. Each student can, therefore, receive twenty weeks of work in the department in which he has a special interest. Many teachers confess that the first year of teaching gave them a much clearer grasp of the subjects they taught than they were able to secure as students. From the point of view of scholarship, the teachers’ assistants learn more by acting in this rôle for a limited time than they could learn by using the time for additional study. They not only learn how to take initiative and assume responsibility, but they enable the teacher to do much more effective work with the regular classes.

This same fundamental principle of organization is applied to the pupils themselves in their relations with one another. Fourth- and fifth-grade pupils are considered too old for the primary manual training and nature-study, and not quite old enough to use profitably the laboratories and workshops as independent students. They are, therefore, assigned as assistants to students in the higher classes. These children in this way learn more by working with the older students than they can be taught in separate classes by themselves. Not only does the younger child learn by helping the older and watching him and asking questions of him, but the older learns by being required to answer the questions and make the younger child understand what he is doing in shop or laboratory. The object is to make the Gary school, in the words of Superintendent Wirt, “as much as possible like a large family wherein the younger children are learning consciously and unconsciously from the older, and the latter from contact with the younger children are learning to assume responsibility and take the initiative. Some one has said that we send our boy to school, but his playmates, not the school faculty, educate him. This is true because in the conventional school the faculty does not utilize the playmates as assistant instructors.” This “helper”

system has proved to be one of the most valuable features of the Gary schools.

For the pupil, organization means a degree of flexibility and individual instruction extraordinary for a public school. Except in the lowest grades, the pupils are classified by subjects as well as by grades, so that practically college methods obtain. Each pupil has his own schedule or program, just as the college student has. The executive principal corresponds to the college registrar in supervising these individual records. The pupil is promoted by subjects and not by grades, and may be promoted or demoted at any time by the supervisor of instruction, acting with the teacher. Grades, therefore, represent merely years of schooling and not classes which are promoted as units. Each regular class has a maximum register of forty, but the class does not work as a unit, any more than a college class of sophomores works as a unit. Some are taking one group of subjects, some another. The work is thus done largely in small groups, or even as individuals. The great wealth of equipment and the economical use of time permit a large amount of practically individual instruction.

The students of each grade are classified into three groups—rapid, normal, and slow workers. The rapid workers can easily complete the twelve years' course in ten years. They may then enter college at sixteen years of age. The great majority of the Gary pupils who go to college actually come from this rapid-working group. The normal workers complete the course in twelve years, and the slow workers in fourteen. Many of the slow workers do not attempt to complete the course, but specialize in the industrial departments. This grouping contemplates the recognition of differences in the mental endowments and ambitions of children of the same age, so that means are provided for the shortening of school life for some children and the lengthening of it for others. Every child is, as far as possible, working along with his equals, so that the bright child is not held back and rendered listless by the presence of slower members in the class, nor is the slow child discouraged by the competition of the brighter ones. Every pupil may go as fast as he can, and may specialize on the work which he can best do. The presence of a

great variety of activities makes it possible for the children who falter on their intellectual work to give more attention to the manual or artistic or physical work in which they may excel.

A special investigation was made in 1914 into the regrading of the pupils of two ninth-grade algebra classes in the Emerson School. The results of regrading the classes into rapid and slow workers showed marked improvement in the interest displayed in the algebra work, especially on the part of the slow workers. No failures were reported among the rapid workers, and only three among the slow workers, and these were due to absence from class. The total class average for the slow division was in three months raised five per cent. In the Jefferson School, which has been operated on the Gary plan longer than any other school, fifty-two per cent of the children are one or more years *ahead* of their normal grades.

Many features of the Gary plan afford extraordinary opportunities for extra assistance in study and work. The pupil may take extra work in a subject during a proportion of his play, auditorium, or shop hours. If he is a member of the "X" school, he may get the same lesson repeated for him the same day by attending the parallel class in the "Y" school held at a different hour. He may come to the voluntary Saturday school and get extra coaching from the teacher, and the vacation school provides additional opportunity to make up back work. No home work is allowed, except to a small extent in the high-school grades. The long school day, and the freedom which the teacher has to distribute her time and to conduct supervised study, obviate the necessity for carrying books away from the school. Since the state law does not authorize the schools to provide free textbooks, these must be provided by the pupil, or, as in the case of most of the Gary classes, bought by the school and loaned cooperatively to a number of classes. Since home work is not permitted, the books may be kept in the school and distributed to the classes as they require them.

The headquarters of the pupil in the school are not in the classroom, as in other public schools. It is the teacher and not the class which is assigned to the room. The teacher remains in the room and the pupils go to him or her, moving about individually from

classroom, shop, laboratory, etc., according to the printed schedule card which each pupil holds. The child's headquarters is the spacious lockers which line the corridors in the basements. Each child has a private locker for books, papers, and wraps. Strictly speaking, the pupil in the Gary school, except in the lowest grades, has no "teacher," except the "register teacher." The departmental system gives him many teachers, but no teacher. This system and the self-governing responsibility for his own schedule is intended to cultivate initiative and responsibility on the part of the pupil. It brings him from an early age into contact with different personalities, gives him the benefit of expert teaching and a variety of movement and exercise. The introduction of these free college methods into the common school is, in the light of public-school practice, a daring experiment, but the Gary school experience seems to show that it is quite possible to give the younger children a large measure of freedom and individuality of treatment.

Most of the schedules of the pupils are arranged with reference to the requirements of the state course of instruction, specialization not being permitted, of course, except in the higher grades, or where some special weakness causes repeated failure. Yet the Gary schools have about twenty per cent of special students who do not intend to finish the course and are specializing in some departments. But since, owing to the individualization of schedules, every pupil is in a sense a "special student," the presence of this large number of students causes no administrative confusion, nor are the special students—as would be the case in many schools operated on a uniform plan—marked off invidiously from those who are following the more regular course.

The segregation of sexes which the visitor finds in some of the Gary schools and courses is not the result of any prejudice against coeducation. (All the activities are open equally to boys and girls alike, so that girls are found in the printing-shop and in the wood-working classes, etc.) It is due to the effort to give each boy and girl what he or she needs. The organization of many classes, such as play, gymnasium, personal hygiene, and the manual activities which do not appeal to the girls, or the domestic science which does not

appeal to the boys, required this unisexual classification, and sometimes it has been retained to avoid the break-up of classes in related subjects.

An example of this effort to provide for all kinds of students in the Gary school is the first-year college work which is offered to students who wish to remain in the school for post-graduate work. The Gary school endeavors thus to overlap the college, just as it has made the common school dovetail into the high school, and the day school into the evening school. When the Gary high-school students have come up through the Gary schools, it is hoped to be able to send students from the local schools at the age of eighteen so prepared that they may complete the ordinary college course in two years.

A word should be said about the interrelation of this flexibility of schedule with the "helper" system. The choice of what subjects the pupil shall study is not as willful and anarchical as it may seem. In the lower grades the regular studies are, of course, prescribed. English, arithmetic, history, and geography must be studied by all, with the attendant "application" and "auditorium" work. All must have physical education, music and expression, and some form of manual and scientific work. The courses in science, industrial work, and music and expression, below the high school, are taken in alternation. Each occupies one third of the school year. The individual choice of the pupil comes in what science or what shop work he or she will take. The beginning is not by chance, but really the result of a natural process of selection by the child. All the early years are made a sort of unconscious prevocational school in which the child tries out his interests and powers. Things are neither forced on him nor aimlessly selected. The child in kindergarten or first three grades moves about the halls and corridors. Since the shops and studios and laboratories are not segregated, but distributed over the building, so that all seem equally significant, the child has every opportunity to become familiar with them. His curiosity is aroused, and, unaided, he is tempted to peer in through the glass doors and windows, and wonder what the older children are doing. When the child has reached the fourth grade, he already has an idea of what activity interests him, and what he would like to try. Fourth- and fifth-

grade children then go in as helpers to the seventh-, eighth-, and ninth-grade students in shops, studios, and laboratories. If the child finds the work does not interest him, he still has a chance to try some other work, and thus gradually sifts out what is likely to be valuable to him for a vocation or avocation. If he has special skill, he may specialize in the higher grades. Such a plan seems to be admirably devised to bring out whatever capacities there are in the pupils, and to insure almost automatically their interest in work which in many schools is mere unintelligent drudgery.

Vocational guidance in such a system is simple and effective. The “auditorium” teacher, in charge of the presentation of material relating to the shops and industries, is able to give information as to the desirability of the several trades and industries as occupations. For example, the school plumber may prepare with his students a plumbing outfit for an ordinary dwelling or apartment, and give a lesson on the way in which plumbing should be cared for in the home. The plumbing instructor may know much about plumbing, but very little about presenting his information to a large body of students. The “auditorium” teacher would assume the responsibility of supervising such auditorium presentations in order that they might be dramatically effective. The day that the plumber and his students present the advantages and disadvantages of plumbing as a trade, the teacher of industries may announce to the boys in “auditorium” period that for the remainder of the week any boy may be excused for a personal consultation with him concerning the desirability of joining a class in plumbing. Students are thus directed in their shop assignments by this “auditorium” teacher of industries. Vocational guidance is thus made possible as far as it is probably wise to undertake such guidance in the school at present. Such a plan directs the mechanically inclined among the children by enlisting their interest and then their will. The “auditorium” teachers for the other activities may also act as advisers in the same way. Teacher and pupil thus coöperate, not in any haphazard fashion, but systematically, in studying the various activities with a view to their future use as a vocation. Such an attitude not only organizes and motivates the work, but gives it seriousness and purpose. Every detail of organization in the Gary school is devised to make the pupil

as well as the teacher an integral part of the school life, not only in its own meaning, but in its relation to the outside world.

VI

CURRICULUM: LEARNING BY DOING

THE Gary curriculum, in spite of its many special features, is neither eccentric nor overcrowded. It follows the regular course of study laid down for Indiana schools by the State Department of Public Instruction. Students who follow the full course may be ready to enter college at the age of sixteen. The additional facilities of the Gary schools are not gained at the expense, therefore, of the ordinary course of education. They are made possible through a more ingenious distribution of time throughout a longer school day, and by an integration and interrelation of subjects which tend to vitalize them all.

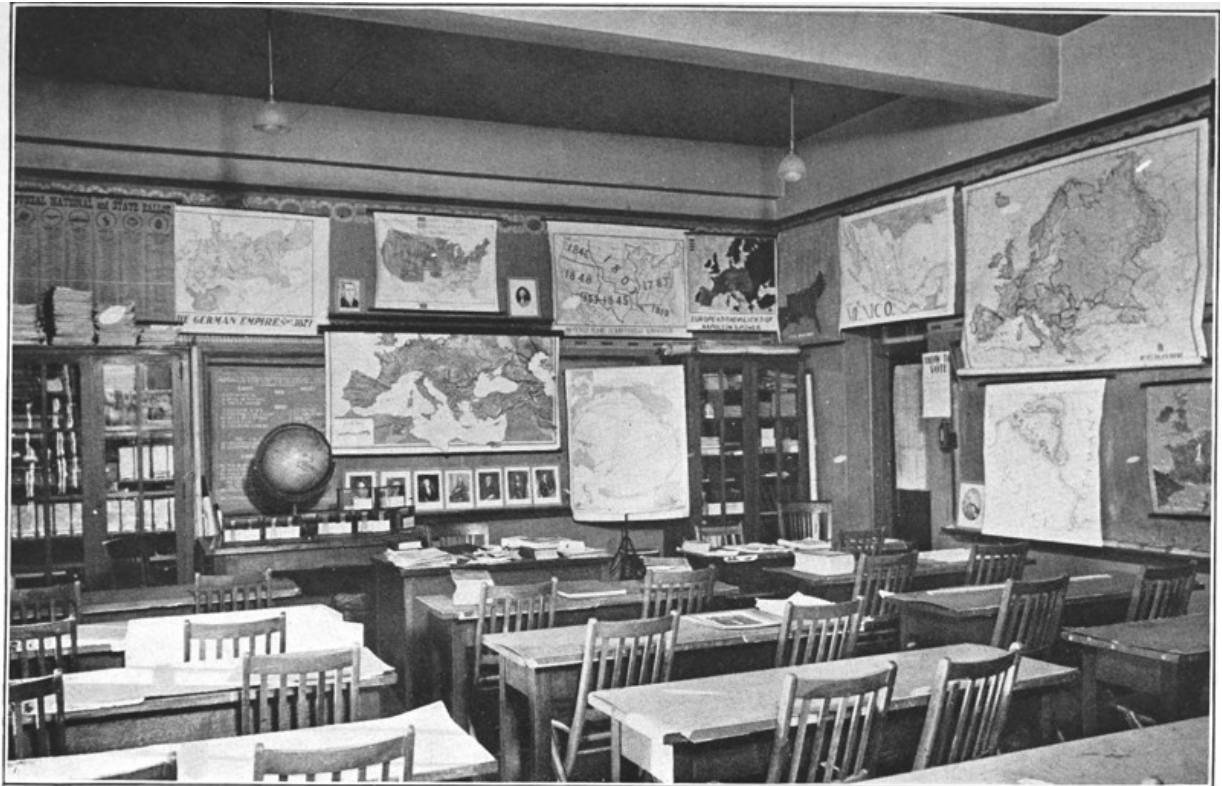
The regular studies in the lower grades are conducted along the conventional lines, with the addition of the "application" work which has been described. The English work is further vitalized through the employment of special teachers for "expression," who alternate with the special teachers of music. "Expression" is a mixture of elocution and dramatics. The aim of the instruction is evidently to bring the pupils to read and speak with more intelligence and appreciation than is usually done. It is to give the training which will bear fruit in increased expressiveness in all the studies of the school, in all writing and reciting, in "auditorium" and "application" work. So far, owing to the peculiar requirements of talent in the teachers and on

account of the lack of good American elocutionary and dramatic tradition, the enterprise can scarcely be called more than a frank and important experiment. For the Gary curriculum with its emphasis on self-activity, such training in expressiveness is essential, and it can be depended upon to improve rapidly in quality as the children and teachers catch the spirit of the schools and get the practice of "auditorium" and "application" work.

The importance of the equable division of time between regular studies and special activities has already been discussed. An important feature of the Gary teaching is the avoidance of that excessive subdivision of subjects which has affected curriculum-making in many schools. History and geography are here uniformly taught together; language, grammar, spelling, reading, and writing are taught as much as possible together as English; physiology is taught in connection with zoölogy. Since the teacher is left much initiative in the distribution of her time, she may emphasize and correlate the different studies as she finds necessary. All the English branches are taught constantly in connection with the other studies. The history or physics class may begin with a spelling-lesson. Compositions in science or history, or the brochures issued by the science departments, are supervised by the English teacher. We have seen how the shop and commercial instructors give special work in practical English and mathematics. The effort is constant in the Gary curriculum to teach a subject, not as an isolated body of subject-matter, but as knowledge which may bear on any or all the other departments of the school community.

Studies are taught also with as much bearing as possible on the social activities of the larger city community. The subject-matter in the history and geography classes is really "The Sociological World we Live in," and textbooks, histories, atlases, globes, newspapers, and magazines become the reference sources and the materials for understanding that world. The working-out of such principles must, of course, be a matter of experimentation by able teachers, and the work cannot be described in any formal manner. Illustrations of some of the successful methods can, however, be given. The history room in the Emerson School, for instance, is found by the visitor to be

almost smothered in maps and charts, most of them made by the children themselves, in their effort to “learn by doing,” and to contribute their part to the school community. A large Indiana ballot, a chart of the State Senate, a diagram of the state administration, a table showing the evolution of American political parties, with many war maps and pictures, covered the walls. The place is a workshop rather than a classroom, with broad tables for map-drawing, and a fine spread of papers and magazines. The ninth-grade Gary children are, in fact, conducting what some progressive colleges have introduced as “laboratory work in history.”



THE HISTORY ROOM AT THE EMERSON SCHOOL

When the writer visited the school, the town of Gary was waging a campaign for a new water-front park. The history class had for some weeks been using this public issue as a text for their work. They had been studying “The City: A Healthful Place in Which to Live (with special reference to parks).” Outlines had been worked up from

reference books in the school branch of the public library. These were read to the class and discussed by them. Such a course became almost one in town-planning, one of the most fascinating and significant of current social interests, and one which packs into itself a maximum of historical, sociological, and geographical information. Such a course provided an admirable motive for a review of history from a practical local point of view which all the intelligent pupils could appreciate. The outline follows:—

The City: A Healthful Place in Which to Live: Emphasis on Parks

1. Athenian recreation centers.
2. Roman opportunities for recreation.
3. Mediæval cities: England.
4. Mediæval cities: Continental Europe.
5. The modern British city.
6. Modern cities in Argentina, Chile, Brazil.
7. The large German city.
8. The small German city.
9. Paris, and the smaller French cities.
10. Colonial cities of America.
11. American cities during the last quarter of the eighteenth century.
12. American cities before the Civil War.
13. American cities from the Civil War to the twentieth century.
14. American cities in the twentieth century.
15. How smaller cities are replanning.
16. Parks in large American cities.
17. The city-planning conference.
18. Statistics showing total area of city, and percentage of park space.
19. Playgrounds of Chicago and New York.
20. The Gary plan of schools and playgrounds on the same site.

The class in ancient history, owing to a belief on the part of the instructor that no child should be allowed to leave school without a background of modern affairs, devotes one day a week to

contemporary history. A weekly digest of the ten most important events is kept in the history notebook, arranged, three for foreign events, three for national events, and four for local. Reports are prepared and read upon assigned magazine articles, especially from the *Literary Digest*, *Outlook*, and *Independent*. Everything is thus done to get the clue of historical study from the interesting events around the pupils. History is studied as much as possible backward, instead of forward.

In 1912-13 the classes in modern history became interested in the past of the Balkan nations, in order to understand the reason for their alliance against the Turkish Empire. A digression was, therefore, made to clear this point, and to vitalize thereby the history of the related European countries. The next year a similar interest was kindled in Mexico and our relations with the Spanish-American republics. During the past year the history instructor has found the study of the last two centuries of western Europe to move along without effort, owing to the interest in the great war.

Such a study of history clearly obviates the necessity of any separate study of "civics." History and geography taught in this way become part of one's general information. Magazines and newspapers are freely used. The systematic reading of the best weeklies and papers surely is an important training, in an age of so much cheap and worthless reading-matter.

One history class had been making a comparison of Athenian with Gary education. This is another illustration of that constant effort to make the pupils realize the meaning of what they are doing and what is around them. The effort of the Gary education is to make the child acquainted with the purposes of his school. He is not taught as an inferior who must take without question wisdom from immensely superior teachers, but as an equal and democratic citizen of his school community, learning wherever and whenever he can. The ancient history class had for its motto: "To improve its members as American citizens by a study of the experiences of the ancient peoples." It would be difficult to imagine a more admirable reason for historical study than this phrase, the natural expression of the Gary

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