Student Water Managers

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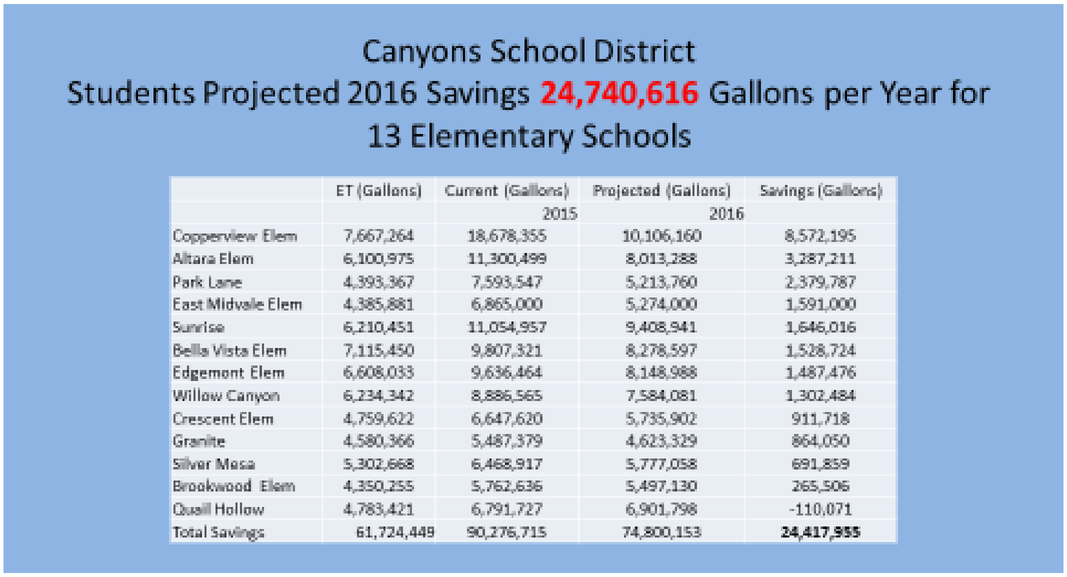
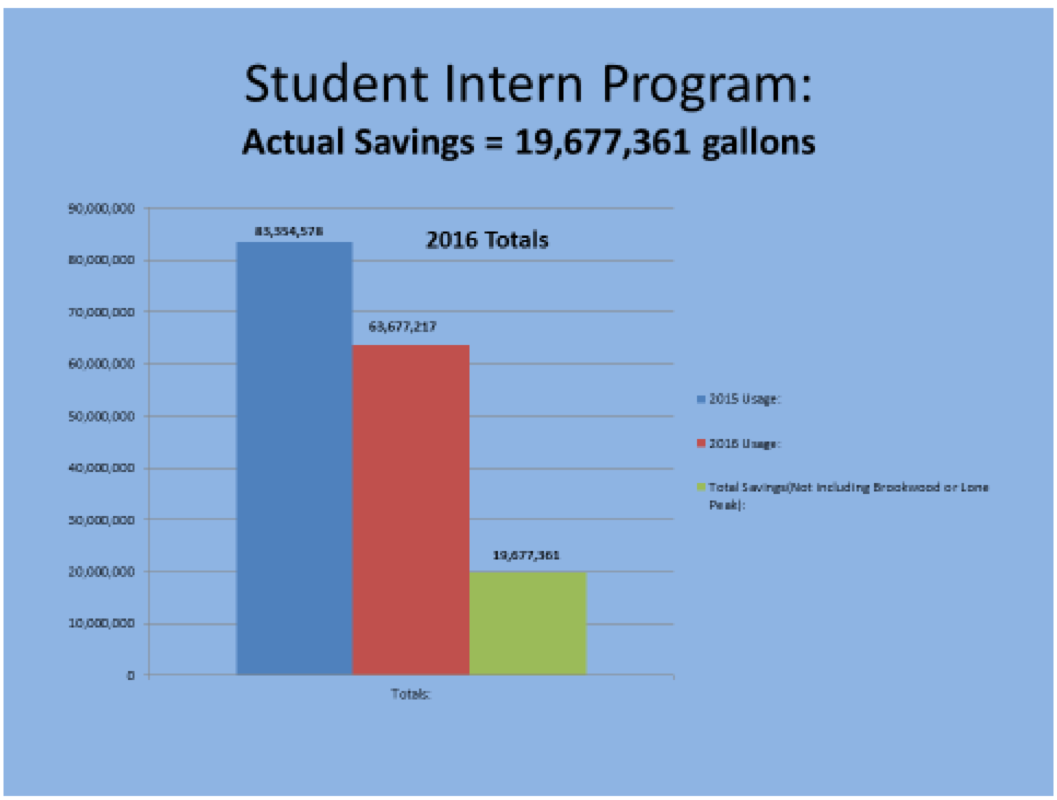
Abstract

Properly trained high school students can become water managers extending a program's ability to gather data to more optimally program irrigation controllers. This saves limited water, critical school district funds, and provides students competitive summer employment. The process of gathering required data to create irrigation schedules can be time-consuming or low-priority for smaller staffs at school districts, universities, cities, and municipal parks. Properly educated and supervised students can identify and document needed information to create accurate program schedules. Students are taught using The Irrigation Training & Research Center's online classes. Students find real-world application for their math, computer and physical science learned in school and develop skills with a potential crossover in future jobs. It deepens their understanding of large landscape actual water needs. We partnered with the Utah Water Conservancy District who provided an annual $10,000 grant to hire students the first two summers. Based on the 2015 field season, students projected a savings of 24,740,616 gallons using their data, combined with historical evapotranspiration rates. After the 2016 irrigation season, 19,677,361 gallons were actually saved. Not reflected in this is a defective meter that could potentially have increased the saving of another eight million gallons.


Canyons School District
Students Projected 2016 Savings 24,740,616 Gallons per Year for 13 Elementary Schools

	ET (Gallons)	Current (Gallons)	Projected (Gallons)	Savings (Gallons)
		2015	2016	
Copperview Elem	7,667,264	18,678,355	10,106,160	8,572,195
Altara Elem	6,100,975	11,300,499	8,013,288	3,287,211
Park Lane	4,393,367	7,593,547	5,213,760	2,379,787
East Midvale Elem	4,385,881	6,865,000	5,274,000	1,591,000
Sunrise	6,210,451	11,054,957	9,408,941	1,646,016
Bella Vista Elem	7,115,450	9,807,321	8,278,597	1,528,724
Edgemont Elem	6,608,033	9,636,464	8,148,988	1,487,476
Willow Canyon	6,234,342	8,886,565	7,584,081	1,302,484
Crescent Elem	4,759,622	6,647,620	5,735,902	911,718
Granite	4,580,366	5,487,379	4,623,329	864,050
Silver Mesa	5,302,668	6,468,917	5,777,058	691,859
Brookwood Elem	4,350,255	5,762,636	5,497,130	265,506
Quail Hollow	4,783,421	6,791,727	6,901,798	-110,071
Total Savings	61,724,449	90,276,715	74,800,153	**24,417,955**



Students

Like hiring any employee, selecting the right students can determine the success of the program. After four years implementing the program, my greatest success has been hiring high school juniors or seniors who come recommended by the Advanced Placement Math department. During a student's interview, a fuller explanation of the responsibilities of the position are discussed. For our program, 6–8 qualified students are optimal balancing my time to instruct and supervise them. I work to create an enjoyable work experience and am flexible with anticipated summer vacation schedules, typically about two weeks off. I have found that structuring the work to be Monday through Thursday, 9 to 2:00 p.m. with a half hour lunch*, allows a balance that keeps youth engaged and focused. Teams work in pairs to collect field data and input into spreadsheets. Once a school is completely evaluated, teams are reassigned new partners. I find this keeps productivity high, and allows different opportunities for students to learn to work together. Field work is done in the morning before the heat of the day and classroom work is done during the afternoon. Students provide their own transportation, logging mileage for reimbursement. Cell phones are allowed for communication and safety. I have found students have been respectful with personal cell phone use while working. Rarely do I need to ask for phones to be put away. (*check with your HR on local employment regulations)

Curriculum

The Irrigation Training & Research Center (ITRC) online classes comprise the curriculum for the program including Basic Hydraulics; Basic Soil-Plant Water Relationships; Distribution Uniformity and Precipitation Rate; Evapotranspiration; and Irrigation System Components.

In the Basic Hydraulics class, the concepts of flow, velocity, and pressure are explained so that students develop an understanding of how water moves in an irrigation system. Students learn about characteristics of pipe size and about how the pipe's physical properties impact water flow.

The Basic Soil-Plant Water Relationships class lays the foundation for principles related to soil moisture content using a sponge to represent soil. Topics covered are soil saturation, field capacity, permanent wilting point, available water holding capacity, management allowable depletion, and soil moisture depletion. It explores the different soil types such as clay, silt, sand, loam and the management allowable depletion (MAD) of each.

Distribution Uniformity Lower Quarter (DUlq) enables students to understand system performance, and how evenly plants throughout a zone are watered. DUlq is used for scheduling irrigation and determining the amount of time the system should run. The students take the average of the lower quarter water applied and divide it by the average of the whole area applied. A catch canister test is performed to determine the DUlq.

The students learn to calculate the precipitation rate (PR) or identify the PR using a catalog. PR is the rate at which irrigation water reaches the ground surface, usually measured in inches per hour. They learn the difference between flow and PR. Additionally, they come to understand the relationship between soil, slope and the precipitation rate, along with the concept of cycle and soak to overcome potential over watering. In order to maintain a healthy turf, students discover that sometimes the zone's lowest precipitation rate must be used to irrigate. Matched precipitation is taught to be the objective of each zone.

Evapotranspiration (ETo) allows the students to understand the combined effect of plant transpiration and evaporation from the soil and plant leaves. Students learn that a landscape coefficient needs to be multiplied by the ETo in order to determine the plant water requirement ETl. The landscape coefficient is comprised of three things: plant type (tree, shrub, turf, flower), plant density (how closely plants are spaced together in an area), and microclimate. Finally, students ascertain daily, weekly and monthly ETo rates collected from the controller and from the Utah Department of Natural Resources, along with how to use ETo in the calculation of their run times.

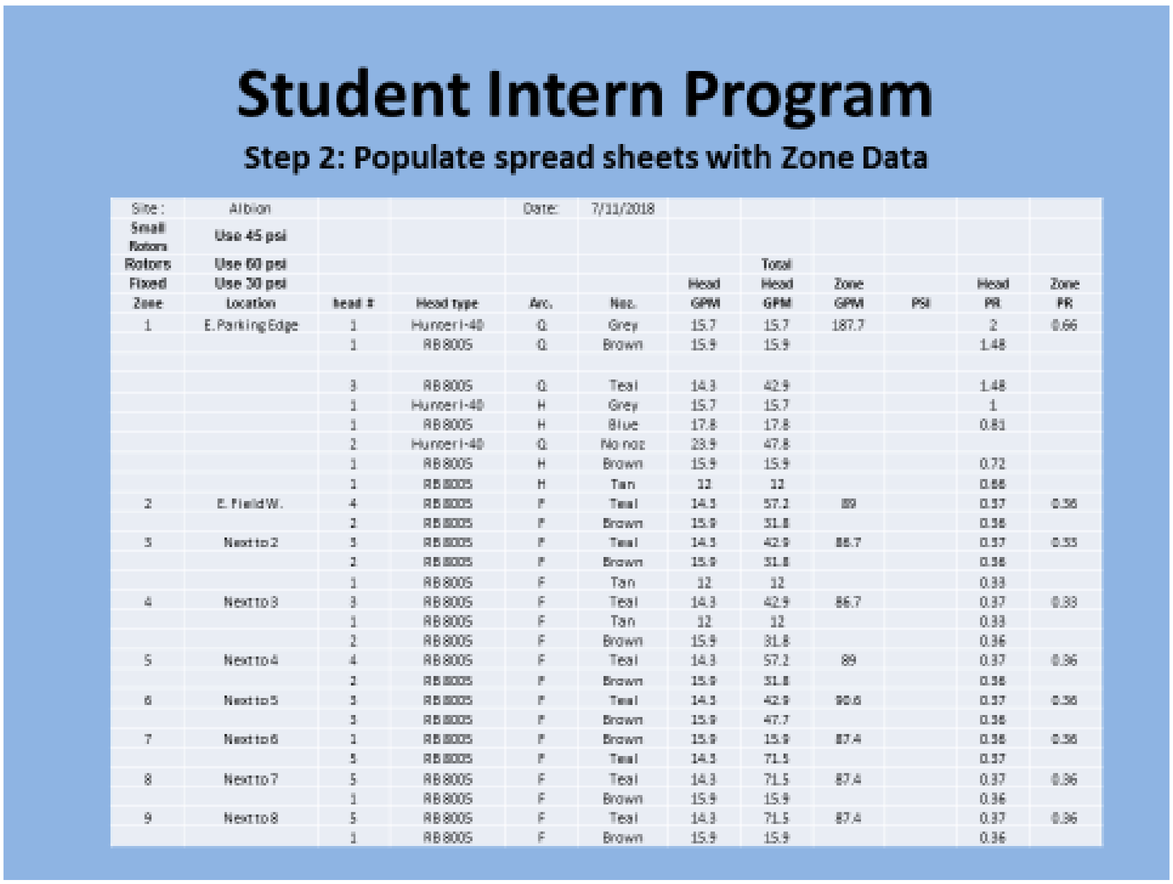
The effective rainfall is the fraction of total rainfall that is actually stored in the root zone. Rainfall can be sometimes ignored, especially when there is a minimal recorded amount.

Prior to the class, few if any of the students have had any experience installing or working on sprinkler systems, so I include a class on system components. This allows them to learn the various irrigation hardware and to begin visualizing the layout of a designed system. Students are not asked to repair or install any irrigation components.

Field and Classroom Procedure

Step 1: Prior to sending students on location it is helpful to notify the custodian that students will be working on the property. Working in pairs, students arrive at a school and introduce themselves to the custodian. They politely explain what they will be doing and when both parties are comfortable, they begin evaluating the sprinkler system. Students first, determine sprinkler type, nozzle size, arc (full, half, etc.), and establish how many heads are in each zone. Any broken, missing, bent, or poorly adjusted sprinkler heads are reported so that a work order can be submitted to the maintenance department. The students responsibility is to collect data not to repair. I ask the students to note landscape material: turf, trees, shrubs or flowers. After an initial observation of the process, students measure the root zone, using either a soil probe or vertical slice of the soil. Students then categorize the area's exposure; full sun, partial sun or shade. Student take steps to identify the soil type by estimating whether it is clay, silt, sand or loam. Proper soil identification includes taking a soil sample to the local horticulture extension office or university for lab analysis. The square footage of the landscape area is determined from Google Earth.

Step 2: Utilizing field data, students enter this into an excel spreadsheet with columns for zone, zone location, number of heads per zone, head type, arc, nozzle, head gpm, zone gpm, psi, catalog or calculated head and zone precipitation rate. The precipitation rate, as well as the gallons per minute, are determined by nozzle color or orifice size. When a zone seems poorly designed, a catch canister test provides a more accurate precipitation rate and DUlq. When pressure looks abnormally low or high, a pitot tube is occasionally used. The students historically have struggled to get accurate psi readings with the pitot tube. Until a zone has a matched precipitation rate, I recommend to the students to input the lowest PR. By doing this we prevent under watering and damage to the turf. I know that this is not ideal water conservation, but landscape costs can be exorbitant and children can get hurt if the play areas become too hard and turf bare. Fortunately, I have been able to get the sport field heads matched within a year or two.



Student Intern Program

Step 2: Populate spread sheets with Zone Data

Site :	Albion			Date:	7/11/2018						
Small Rotors	Use 45 psi										
Rotors	Use 60 psi						Total				
Fixed	Use 30 psi					Head	Head	Zone		Head	Zone
Zone	Location	head #	Head type	Arc.	Noz.	GPM	GPM	GPM	PSI	PR	PR
1	E. Parking Edge	1	Hunter I-40	Q	Grey	15.7	15.7	187.7		2	0.66
		1	RB 8005	Q	Brown	15.9	15.9			1.48	
		3	RB 8005	Q	Teal	14.3	42.9			1.48	
		1	Hunter I-40	H	Grey	15.7	15.7			1	
		1	RB 8005	H	Blue	17.8	17.8			0.81	
		2	Hunter I-40	Q	No noz	23.9	47.8				
		1	RB 8005	H	Brown	15.9	15.9			0.72	
		1	RB 8005	H	Tan	12	12			0.66	
2	E. Field W.	4	RB 8005	F	Teal	14.3	57.2	89		0.37	0.36
		2	RB 8005	F	Brown	15.9	31.8			0.36	
3	Next to 2	3	RB 8005	F	Teal	14.3	42.9	88.7		0.37	0.35
		2	RB 8005	F	Brown	15.9	31.8			0.36	
		1	RB 8005	F	Tan	12	12			0.33	
4	Next to 3	3	RB 8005	F	Teal	14.3	42.9	86.7		0.37	0.33
		1	RB 8005	F	Tan	12	12			0.33	
		2	RB 8005	F	Brown	15.9	31.8			0.36	
5	Next to 4	4	RB 8005	F	Teal	14.3	57.2	89		0.37	0.36
		2	RB 8005	F	Brown	15.9	31.8			0.36	
6	Next to 5	3	RB 8005	F	Teal	14.3	42.9	90.6		0.37	0.36
		3	RB 8005	F	Brown	15.9	47.7			0.36	
7	Next to 6	1	RB 8005	F	Brown	15.9	15.9	87.4		0.36	0.36
		5	RB 8005	F	Teal	14.3	71.5			0.37	
8	Next to 7	5	RB 8005	F	Teal	14.3	71.5	87.4		0.37	0.36
		1	RB 8005	F	Brown	15.9	15.9			0.36	
9	Next to 8	5	RB 8005	F	Teal	14.3	71.5	87.4		0.37	0.36
		1	RB 8005	F	Brown	15.9	15.9			0.36	

Step 3: The students calculate the ideal zone run time, run times per cycle, and irrigation days per month. I have taken the Irrigation Association Audit worksheet and made it into an excel sheet for each zone. I have made the sheet interactive so as I change values, the sheet updates. The exercise allows each student to have an understanding of how DU, PR, root zone, and soil type affect the irrigation schedule. As values change for each of the zone characteristics, so does the run time.

Student Intern Program

Step 3: Calculate Ideal Zone Run Time

Project Name: Altara Elementary								
Location:								
Date:								
Soil Type: : Sandy Loam								
Plant Water Requirement		April	May	June	July	August	September	October
		16.07	4.12	3.25	3.05	3.32	8.07	35.47
Plant Material								
Reference Period								
Reference ET	in. per mo.	1.28	4.99	6.32	6.75	6.2	2.55	0.58
Landscape Coefficient		0.7	0.7	0.7	0.7	0.7	0.7	0.7
Allowable Stress								
Plant Water Requirement	inches	0.896	3.493	4.424	4.725	4.34	1.785	0.406
Irrigation Water Requirement								
Precipitation Rate	in. per hr.	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Distribution Uniformity		0.6	0.6	0.6	0.6	0.6	0.6	0.6
Irrigation Water Requirement	inches	1.49	5.82	7.37	7.88	7.23	2.98	0.68
Total Run Time per Period	minutes	91.43	356.43	451.43	492.14	442.86	182.14	41.63
Scheduling Requirements								
Root Zone Soil Type								
Available Water	in. per hr.	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Active Root Zone Depth	inches	8	8	8	8	8	8	8
Plant Available Water	inches	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Allowable Depletion		0.48	0.48	0.48	0.48	0.48	0.48	0.48
Irrigation Days per Period	days	1.87	7.28	9.22	9.84	9.04	3.72	0.85
Total Run Time per Day	minutes	48.98	48.98	48.98	48.98	48.98	48.98	48.98
Run Time per Cycle	minutes	19.63	19.63	19.63	19.63	18.63	18.62	18.62
Cycles per day								
Corrected Run Times	minutes							

Step 4: The students create an irrigation schedule. Included in this schedule are the zone run times, the days between irrigation cycles, and the gallons used for each cycle. The students can then sum the gallons for a complete cycle and estimate annual irrigation. These calculations are based on historical ET.

Since 2017, the controllers are operating using daily ET along with the information gathered in the field and input into the step 2 spreadsheet. I continue to have the students calculate a run time schedule as a learning experience.

Student Intern Program:

Step 4: Implement a Calculated Schedule or Water to Evapotranspiration Rate using Calculated Precipitation Rates

Evapotranspiration is the sum of evaporation and plant transpiration from the Earth's land and ocean surface to the atmosphere.

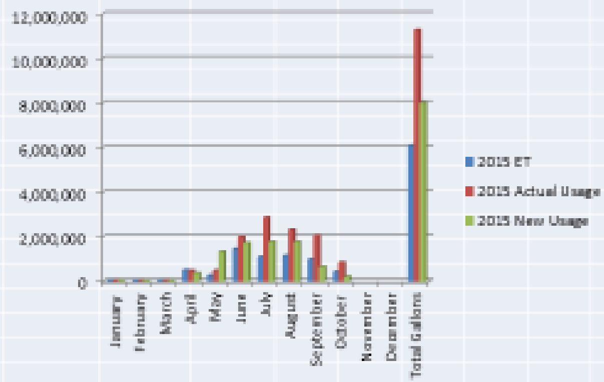
Altara											
		GPM	Gallons per cycle	Time	April	May	June	July	August	September	Ocotober
zone:	description										
a-2	East field center	75.8	8,461	111.63	16.07	4.12	3.25	3.05	3.32	8.07	35.47
a-3	West curb east field	139	9,016	64.86	16.07	4.12	3.25	3.05	3.32	8.07	35.47
a-4	adjacent to a-2	154	9,357	60.76	16.07	4.12	3.25	3.05	3.32	8.07	35.47
a-5	adjacent to a-4	93.6	7,131	76.19	16.07	4.12	3.25	3.05	3.32	8.07	35.47
a-6	adjacent to a-5	52.5	4,941	94.12	16.07	4.12	3.25	3.05	3.32	8.07	35.47
a-7	void										
a-8	Along 110 south east side	86.5	2,386	27.59	16.07	4.12	3.25	3.05	3.32	8.07	35.47
a-9	Along 110 south west side	75.1	2,072	27.59	16.07	4.12	3.25	3.05	3.32	8.07	35.47
a-10	Front west corner	32.85	906	27.59	16.07	4.12	3.25	3.05	3.32	8.07	35.47
a-11	West front perimeter fence	66.3	1,829	27.59	16.07	4.12	3.25	3.05	3.32	8.07	35.47
a-12	West side building	39.8	1,098	27.59	16.07	4.12	3.25	3.05	3.32	8.07	35.47

Step 5: Students calculate an estimated monthly water use amount from historical ETo, DU, and landscape acreage and compare it to the billed water use for the site. Inside water use is taken into consideration. First, the landscape acreage is multiplied by 27,154 gallons to determine the gallons of water for 1 inch of water over the landscape site. Second, the monthly ETo is divided by a determined distribution uniformity percentage, to get a value for the required irrigation in inches for that month. Third, the required irrigation for each month is multiplied by the gallons for the landscape area. The calculated value is the total gallons estimated for that month. This value is compared to the actual usage. The difference between the two represents an estimation of how close the program irrigated to ETo.

Student Intern Program

Step 5: Compare Estimated Turf Water Requirement to Actual Water Use

Altara Elementary			
Custodian		Elisa Rodriquez	
Sq. Footage		270,508	
Acres		6.21	
1 Acre Inch		27,154	gallons
Site Acre In.		168,626	gallons
Estimated Inside Usage		40,000	gallons
	2015	2015	2016
	ET	Actual Usage	New Usage
January	40,908	40,908	40,908
February	40,000	40,000	40,000
March	47,631	47,631	47,631
April	518,683	502,645	376,742
May	268,554	504,831	1,344,874
June	1,468,611	2,007,911	1,723,708
July	1,106,626	2,873,401	1,779,832
August	1,165,084	2,337,438	1,779,832
September	996,457	2,082,594	671,391
October	448,422	863,140	208,371
November			
December			
Total Gallons	6,100,975	11,300,499	8,015,288



Conclusion:

Canyons School District has found sufficient value in the student water management program to employ students as summer employees. Students fill the void of needed staff to oversee the landscape irrigation. I realize that the program has to make assumptions in order to oversee the many large sites, but the students are all instructed to follow proper water management protocol learned through the Irrigation Training & Research Center. The program no longer applies for, or is dependent on, grants from the The Central Utah Water Conservancy District. Canyons School District now employs the students. By identifying interested, committed students with a willingness to learn, a productive and effective program can be built.

References

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