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Teaching Application-Based Estimating: Integrating the Workplace and the Classroom

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Estimating in construction is often considered an art, which takes time and experience to cultivate. However, estimating can be taught effectively in a construction management program by integrating the workplace and the classroom to better prepare students for what they will face upon graduation. Described in this paper are several successful application-based teaching methods which I have developed over eleven years of teaching estimating. These methods allow students to develop the skills and insights necessary to successfully perform an estimate.

Key Words: Estimating, Construction Management, Application-Based Teaching

Introduction

Estimating in the construction industry can be defined as a compilation of material and labor prices submitted as a competitive bid for the cost of a building a particular project. Yet, as simple as this sounds, estimating goes far beyond punching out numbers to come up with the lowest possible bid. There is an art to estimating which takes time and experience to cultivate.

Many contractors have stated that graduates will learn more about the construction industry as a whole from performing estimates during their first two years on the job, than their counterparts who are hired as project managers or assistant superintendents. The reasons are obvious – estimators will read more specifications, examine a wider variety of working drawings, and gain more knowledge on materials and methods than those who only work on one or two projects in the same time span. I definitely agree with this statement from my previous professional experience as an estimator and project manager and currently as a consultant in the area of estimating. The importance of estimating to a construction firm cannot be overemphasized.

Regrettably, estimating isn't always given the status or importance that it deserves when compared to other subjects taught in construction curriculums. One reason is that many educators teaching construction courses are trained in areas other than construction, such as architecture or engineering disciplines, where estimating is mentioned, but not covered in depth. Additionally, some educators believe that estimating cannot be effectively taught in the classroom, but must be learned on the job. However, construction firms are looking for graduates who not only have the basic skills needed to compile an estimate, but also have the ability to think critically and independently.

How, then, can we teach estimating effectively given the small amount of time that most curriculums devote to the subject? The solution is relatively simple. Teach estimating in an application-based format. Break away from prevalent traditional teaching methods, which are based on assimilating theoretical concepts in isolation (Rosenbaum, 1996). Many methods used to teach estimating are very abstract, sequential and linear in application -- a paint-by-numbers approach (Kirk & Wentz, 1996). Over eleven years of teaching estimating, I have developed several methods where students learn to apply previous knowledge, build on that knowledge and develop independent thinking skills, which will enable them to perform successful estimates and, hopefully, encourage them to be lifelong learners.

Why Application-Based Methods are Needed

In 1955, a landmark report was published titled the Grinter Report, which called for greater emphasis on incorporating scientific principles in education. The subsequent launching of a series of unmanned satellites by the Soviet Union called "Sputniks" gave the Grinter Report validity; since our country seemed to be falling behind when it came to scientific principles. Prior to the report, many post-secondary engineering curriculums were based on an underlying tenet which was job-oriented, very practical, not too rigidly science-based, more of a gild, crafts approach (Rosenbaum, 1996). Construction education programs began evolving (usually from colleges of engineering or architecture) soon after the Grinter Report was issued and the cold war began, consequently falling under the influence of theoretically- and scientifically-based teaching philosophies.

More recently, the education pendulum has been returning to the application-based position. There has been an outcry for application-based education, especially in schools of engineering. This outcry is due in part to the overwhelming amount of information and technology now bombarding not only students, but to citizens in general. This point is illustrated by Rick Grigsby, President and CEO of Grigsby Construction, in Precision Vantage Point Newsletter where he states some staggering figures:

> If you don't believe the world is changing consider this: Forbes Magazine recently said that the industrial revolution increased productivity approximately 100 times. The electronic revolution has increased productivity of information 1 million times. It is expected to increase another 10 thousand times in just the next few years. It took 200 years for information to double in this country the first time. The last time it doubled, it did it in 18 months. Experts are predicting that within the next few years it will double every 2 months.

One may agree or disagree with Mr. Grigsby's figures, yet the fact cannot be argued that information and technology are increasingly flooding our environment. No longer can educators teach theoretical principles without teaching the application of those principles. At the same time, students must "learn to learn and, more importantly, learn to think", (Hendley, 1996) in order to apply knowledge in a meaningful way.

As educators, we must break away from traditional, linear teaching methods based on assimilating theoretical concepts in isolation, i.e. the classroom. This teaching philosophy is based on an outdated theory called "objectivism", which holds that knowledge exists independently of the mind and can be transferred to a student, as if the information is poured from a pitcher of knowledge into an empty vessel of the student's mind (Rosenbaum, 1996). Changing our teaching philosophy might be difficult since most of us in higher education have held this theory as gospel because it is the way we were taught. Yet, we cannot continue to teach in this way and send graduating students off into a world where information is changing every two months.

The bottom line is, students need to learn how to teach themselves by applying knowledge and reinventing the world around them. Many courses in construction lend themselves to this application of knowledge. And, since estimating is vital to any construction company, estimating should be taught in an application-based, realistic approach and away from the objectivism approach, which is prevalent in many construction curriculums.

Key Elements in Application-Based Estimating

A majority of U.S. contractors are classified as small to middle size, thus many construction management graduates will at some time in their careers be required to perform estimating tasks along with scheduling and project management. Therefore, graduates of construction curriculums must have comprehensive instruction in estimating, including bidding, to be successful in the workplace.

Estimating is generally categorized into three areas: quantity survey, pricing, and bidding. To adequately cover each of these areas, a construction curriculum should offer a minimum of two estimating courses, 3 credits (semester credit hours) each, with a possible third elective course. Within the two courses, four application-based methods should be covered: *quantity survey, pricing activities, bidding strategies,* and *simulated bid exercises.* These methods culminate in having the students perform *actual bid projects.*

Through these application-based methods, the workplace and the classroom can come together to provide a realistic learning environment, which prepares students for what they will encounter in their profession.

Quantity Survey

To truly teach the concepts of quantity survey, or take off, it needs to be completed by hand in lieu of computer take off. That may be counter to the advancement of computer applications, however, computer applications are designed as a tool to aid estimators in producing estimates faster, and hopefully more accurately, not as a learning tool to teach the art of quantity survey. Students need to first gain an understanding of what is involved when creating an estimate by being able to read a set of drawings and see the relationships of the various parts within the project. Students must be brought along a developmental curve of understanding and apply

previously learned knowledge in order to acquire the critical thinking skills needed to comprehend the complexity of any given project.

> Critical thinking in estimating includes the ability to visualize a project in its totality. This requires the ability to study a two-dimensional plan and "see" a three-dimensional product. Further, the estimator must view the project as a series of interrelated systems, each dependent on the other. Finally, the estimator must have the ability to identify areas that represent future pitfalls and conflicts, and which must be accounted for within the estimate (Kirk & Wentz, 1996).

I find that when students use a keyboard or digitizer, they see estimating not as an art and a relationship of the various parts, but a means to quickly create a take-off. Students learn that they must walk before they can run. And, although many contractors now have computers, they want graduates who can grasp these complex relationships. This sentiment is echoed in a recent Engineering News Record (ENR) article titled, "Preparing for a New Generation" by Tim Grogan where he interviewed Don Greenland, president of Nabholz Construction:

> Good estimating requires the ability to apply construction expertise to the numbers. One of the most troubling trends is the growing number of applicants for estimating jobs who are computer literate, but who know little about construction. We see kids who are computer whizzes, but couldn't build a dog house.

Thus, with pencil in hand, teach the students in an application format the art of quantity survey. Once the fundamentals have been acquired, the computer can then be introduced as a tool of expediency.

Pricing Activities

In the pricing portion of an estimating course, one of the goals is to obtain current and representative costs through rapport with the local industry. As an art, estimating is more than pulling numbers from references such as Means Cost Estimating Guide or Walkers. Students need to know the meaning of these numbers, or, as we say, make the numbers "talk".

Students should perform several classroom activities in unit costs preparation. I like to refer to these as "work-up sheets". On work-up sheets students create unit costs for various parts of a project, such as a monolithic, one-way slab pour. Students learn about the materials and labor involved and how they relate to other factors, such as time and function of the project. They learn how to obtain current prices from the industry by actually calling local material suppliers and subcontractors. This is difficult for most students at first, yet it is important that they learn to communicate in a professional manner with people in the industry and to apply the information obtained.

Occasionally some subcontractors and suppliers are reluctant to work with the students. When this happens, I contact the subcontractor or supplier and explain the classroom exercise. In eleven years, I have had only one contractor who refused to participate. Indeed, most companies

actually want to do more by providing material samples, personal consultation, and even guest speakers. This contributes to building a positive relationship between our program and the local industry.

As they do work-up on various projects, the students record the prices on "quotation sheets". They learn to fill out these sheets including details like time, date, phone number, material description, etc., which is needed for ethical and legal considerations, learned later.

Students must review and thoroughly understand the specifications given in order to determine appropriate unit costs and construction activity scheduling. For example, if the project given starts in late fall or winter, they must adjust unit costs for concrete pours, etc. that may be affected by adverse weather conditions.

When pricing out labor, have the students develop visualization skills. In other words, based on the their prior knowledge, or there ability to seek new knowledge, have them develop labor figures based on productivity that they create without the aid of a Means Cost estimating guide. One example of an exercise that I use to promote critical thinking in creating a unit cost is the curved wall exercise. (Note: This is one of many. Try to develop a number of these so they don't get passed along to the next student class.) In the curved wall exercise, the object is to develop the line item unit cost for material, labor and equipment for a concrete wall with a described radius. At first students resent performing such exercises because they find that thinking critically is difficult. Also, they have a tendency to want to look up items instead of creating the needed information. The point that I attempt to get across is that the solution is not found in Means or other publications.

In the past eleven years of performing such exercises, I have found that 80% of the students will be within 5% of each other and the actual unit cost. These application-based exercises build the students' confidence and show them that they can estimate when they apply knowledge or create new knowledge independent of outside sources.

Keep in mind; it is not important to cover <u>all</u> aspects of any given project when teaching students to think critically. It is more important to teach them to think *independently*, based on a philosophy that estimating is an art, which is cultivated by applying and building upon knowledge. If one attempts to address every aspect of estimating, the students are merely having information poured into their heads, without being given the needed tools to teach and develop themselves as estimators. Also, these exercises can just as easily be performed by hand or on the computer.

Bidding Strategies

Once students develop the skills (and probably more importantly, the confidence) in creating unit costs, they are ready to be introduced to bid strategies. The two general types of construction bids, negotiated and hard bids should be covered separately. Negotiated bids can be covered in senior capstone courses, for they involve many other aspects than merely creating an estimate. For example, skills in communication -- writing, speaking and presentation – should be addressed. The focus in the estimating courses should be on the hard bids. Graduates as well as

contractors have informed us that students should learn hard bid strategies to adequately prepare them for the real world, since most graduates will be placed in hard bid situations. Negotiated bids have a much different process and are usually performed by senior level estimators.

Bidding is probably the most critical portion of an estimate. The major reason is the pressure placed upon bidders on bid day. The bidder's reaction to this pressure can directly affect the success of the bid, and ultimately the success of the company. As Paul J. Cook relates in *Bidding for the General Contractor.*

> Bidding deals with a multiplicity of variables, i.e., the bidder makes a series of many choices. The bidder makes these choices guided by convention, experience, personal preferences and values. The bidder's personality greatly affects the bid, by such traits as idealism, aggressiveness, or conservatism. These influences, however, tend to dissipate as a bidder accumulates experience. …many inexperienced bidders are active in the industry, learning the hard way and 'winning' a great number of contracts at unnecessarily low prices. Evidence points to the probability that organizations can and often do fail because of poor bidding.

Strategies in successful competitive bidding not only include a solid understanding of the elements that make up a bid, but how to effectively formulate and execute the bid under intense pressure. In my second semester estimating course, this pressure is simulated in a series of exercises that the students have coined "hot-seats".

Hot seats are unannounced and the students must be prepared to perform them at any time. This anticipation adds to the pressure atmosphere of the exercise. Each hot-seat lasts from 45 minutes to 1 ½ hours depending on the topic, and generally involves coming up with a bid number from analyzing a list of subcontractor prices, or breaking matrixes, or dealing with alternates, and so on. During the exercise, I do all sorts of outlandish things, including yelling and pounding on desks, to distract the students from their task. One might compare it to a drill sergeant hammering on a new recruit. Indeed, I try to make it as difficult as possible for them to concentrate on the task. The students really get competitive when I mention that in eleven years only five students have ever come up with an accurate number. The object is not for the students to achieve an accurate number, or as a means for a grade, but to teach students to overcome pressure and have confidence in their ability to make difficult estimating judgments under immense tension.

Now, this is not how we teach human factors in construction. Nor do estimators act like drill sergeants on bid day to add to the pressure of bidding. If you have ever been active in bidding projects, it is one of the most stressful situations one can find themselves in and truly the object in real life is for cool heads to prevail. However, the ability to stay cool under pressure is a learned trait. Therefore, hot-seats serve four important purposes: 1) they teach students to focus on the task at hand; 2) they prepare students for pressure situations in the live bid exercises and the real world; 3) students learn how they personally react to this pressure; and 4) I can evaluate each student's pressure tolerance and help them accordingly.

Simulated Bid Exercises

Once the groundwork has been accomplished with these preliminary exercises, simulated bid exercises can then be introduced. Again, the goal is for each exercise to simulate a real bid situation so that the students can acquire necessary estimating skills, along with an ability to make quick, accurate and ethical decisions to successfully bid a project.

Two simulated bid exercises can be performed during the second semester of estimating. I must emphasize one point here – new projects must be used each time with plans and specifications as complete as possible. Do not repeat exercises. They only create files for students to access and increase the temptation to cheat. When students see that new projects are continually being added, they have a tendency to respect the class and the instruction more by the dedication placed on the subject. I know the difficulty here is having the time to estimate a new project, let alone two of them, per semester, however it is essential in order to maintain the integrity of the exercises. I use projects that I have estimated for various contractors through my consulting, or have found contractors who are more than willing to share their estimates.

An important point to mention here is that the second semester should have an attached lab of preferably three hours per week in order to successfully accomplish these exercises. I believe that an estimating class must have designated lab hours to give this subject the true dedication that it needs.

The first bid exercise should be a fairly simple project, such as a commercial project stick frame, slab on grade, or a sub level with a price range of $200,000 to $500,000. The specifications and drawings should be as complete as possible. One reason I keep it simple is that the students are required to do the first exercise entirely by hand with no computer work. This gives the students a better feel for how the numbers are determined. They can then transfer this knowledge to the computer, which is used in subsequent exercises.

Students are divided up into construction “companies” in groups of three. I designate the members of each company to achieve a mix of personalities, talents and strengths for a realistic balance. Each company selects its own name, and creates its own overhead costs based on information (salary, personnel, office rent, etc.), which I provide. The students then obtain costs to formulate their unit pricing as they prepare for bid day.

Another key element in bidding is securing a bid bond. I find that local bonding companies are delighted to work with students, treating them as semi-real contractors in creating bonds for them. The students present their bond application to the bonding company, have the company scrutinize it, and, when everything is in order, are given a bid bond. The students learn that to bid a project, one must have the proper financial backing -- which they create when they form their companies, utilizing their business management course work. Also, they have the responsibility of doing this as soon as possible, for the bond must be secured and included in their packet for bid day.

The simulated bid process usually takes about four weeks, which closely parallels an actual bid process. During this time I prepare at least 75 sub quotations and recruit as many as 30 volunteer

callers to act as subcontractors for bid day. The volunteer callers read from sub quotation sheets, which I have scripted to reflect a real sub bid. This takes a lot of orchestration to put this all together, but if planned well, everything should go smoothly.

Bid day is usually scheduled on a Wednesday with a bid opening time of 5:00 p.m. Each student company picks up a packet from me at noon that day containing some early prices. Then they go to their homes or apartments and begin preparing their bids. Around 1:00, their phones start to ring as the volunteer subs call in their prices. During the four hours each student company may get about 40 phone calls. In addition, they can call me (as a sub) to clarify or question certain prices. This produces a pressure-filled atmosphere similar to what they will encounter on the job. The students must be able to think quickly, analyze quickly, act professionally, and compile a reasonable, competitive bid.

About 30 minutes before bid time, a "runner" from each student company reports to the bid-opening site. The site can be either on or off campus. Runners are still receiving updates from their companies up to the last minute when they must write down their final number and seal it in the envelope with their bid bond. The envelopes are submitted to the actual architect of the project who then reads the bid aloud.

The second bid exercise follows the same procedure as the first, but is done with the computer. This simulated bid exercise is much more dynamic than the first one. It includes alternates, Disadvantaged Business Enterprise (DBE) requirements, cross-reference prices requiring matrix analysis, and ethical dilemmas such as incomplete or unrealistic prices, or quotes that do not comply with the plans and specifications. Sometimes students do not receive complete coverage from subcontractors, so they must come up with their own numbers on very short notice. The project is usually more complex, including steel and other quantities not covered in the first exercise, and has a price range of $1 million to $3 million.

Actual Bid Projects

Actual bid projects can be included in the second semester estimating class in place of the second bid exercise, or in a separate elective course. Again, as with the simulated bids, students work in groups of three, forming construction "companies" and registering these companies with the Nebraska Department of Roads. Working in conjunction with the Department of Roads over a period of three weeks, the students compile their estimates and proceed to bid under actual conditions utilizing real specialty contractor quotations. Their bids are read aloud along with other actual contractor bids. The only difference is that the student companies are not legally bound to enter into contract under orders of the state attorney general's office. These projects are usually bridge projects, but can be buildings, such as office remodels, or rest areas that the state has issued.

The reason for the bidding state work is threefold. One, it offers students who desire to learn the estimating methods and procedures found in heavy estimating a means to do so. Estimating commercial construction projects is in many respects different than estimating and bidding heavy construction projects. Second, the professor only needs to work out the legal parameters and relationship with a single owner. It is much easier to go through the owner permission process

one time with the state, than many different times with various other owners in subsequent semesters and projects. And third, through successful exercises, you can establish a positive reputation and rapport with the many specialty contractors who will be submitting quotations to the students as well as the actual contractors who will bid along with your students.

The dollar size of these projects is very important. They must be large enough to challenge the thought process and to test the students' ability to estimate, yet small enough so they can comprehend the projects. I have found that for the first project, a county bridge between $300,000 to $500,000 is ideal. Usually included in this bid is the demolition of an existing bridge and the re-routing of traffic. In an elective class where the students have participated in bidding actual projects before, I have had some of them successfully bidding projects as large as $5 million.

Preparing these actual bid projects is not as complicated as it may seem. Here is an overview of the steps required to establish this application-based method:

1. First, contact your local department of transportation or department of roads and explain the objectives of the exercise. Gain their approval to continue.

2. In conjunction with the department, contact your state attorney general's office to work out the legalities of the student bid process. This was not as complicated as it sounds. The main reason for this cautious step is to protect your department and students. What if a student company is the low bidder? Are they obligated to enter into the contract? Our state attorney general's office requires the readers of the bids to announce a disclaimer statement when the bids are read aloud that the university labeled group cannot be considered to construct the project if low. This is the only difference and special consideration given to the students on reading their bids. Interestingly, because we have now bid on numerous projects over the past four years, they sometimes do not read the statement when the student bids are read as directed, for it is understood.

3. The next step is to have the student companies registered with the state as viable contractors. Before they can obtain drawings, they must become qualified bidders by preparing state approved financial reports. These reports are again created using fictitious dollars from their made-up companies. However, because the state audits these reports, the dollar amounts represent factual numbers. Obviously, the state understands these are student companies. However, if the paperwork is not completed correctly, they do not receive drawings.

4. Next, notify your local contractor associations and advertise in their local and state publications so that the contracting industry understands what you are doing. Communication cannot be stressed more if you are to gain the respect and trust of the contractors. The student companies must also get on the proper bid list. The local AGC and ABC can be of valuable assistance here. Our local heavy AGC organization has been very cooperative in listing the student companies right along with the other actual contractors. In fact, many times there is no way to differentiate the student companies from the actual contractors. However, I do require that the student groups identify

themselves by providing the initials of the university after their company names. Other than that, there is no other distinction.

5. Then we find a contractor to "sponsor" a student company. Not for monetary support, but to help cost line items which would be difficult for me -- and especially the students -- to create, such as a batch plant for concrete in remote locations, or other unknown factors.

6. The next step is to establish student company telephone numbers, addresses and fax numbers so that they can receive specialty bid prices from contractors. The student companies set up in either our computer lab utilizing our department's fax, or at their homes with an answering service using their personal addresses and obtaining their own fax machine. Both of these company setups have been successful.

7. The final step is, of course, having the students formulate their estimate and prepare for bid day. Usually this occurs over a 3-week period for each bid they perform.

Note: If it is difficult in your location to travel to your state's Department of Transportation or Department of Roads, check into electronic communication. Many state departments now utilize the computer to not only download plans to remote locations, but also perform bids electronically.

These actual bid projects have been very successful. On the very first bid project, one student group came in second out of nine bidders on a large bridge project. At least three times they have been low with very respectable numbers as well placing second and third countless times. Many student groups are in the middle of the pack of bidders with very competitive bids.

However, being low, or second, or even third is not the goal. Our goal is to have the students acquire worthwhile experience by participating in an actual bid where they can see that their numbers really mean something, and allow them to gain experience based on applying pervious knowledge from an application-based method. In doing so, the students gain the respect of the contractors by integrating the classroom with the real world. Personally, there is nothing more gratifying to me than to see the students' faces when they are publicly acknowledged and praised by professionals in the industry.

Conclusion

As you may have concluded, setting up these application-based methods takes an enormous amount of time and dedication. However, they require no more time than any other new course. Also, one might think that these methods can only be effective with small class sizes. Of course we would all like to teach to small classes, but I have consistently taught these methods to classes of as many as 36 individuals without difficulty.

To effectively teach construction estimating, we must teach with realism in mind. The simulated and actual bid exercises described in this paper have benefited the students, local construction industry and our construction program. Students learn in a realistic environment what they will

encounter on the job, develop specific estimating skills, gain practice in professional conduct, and discover how they deal with the stress involved. Some may decide that estimating is not for them, and choose jobs in scheduling, field engineering, or other areas not directly related to estimating. Local industry people can observe and participate in the students' learning process, contribute useful knowledge on current prices and industry practices, and provide valuable feedback on their expectations of graduates. This enhances communication and rapport between industry and academia, which in turn assists us in designing effective course work in construction education.

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