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What is Learning in the Mathematics Classroom?[1]

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What is learning in the math classroom? Does a new term need to be coined for learning? Is the term over-used and it has lost it meaning? The responses of one hundred five teacher-candidates and graduate students were coded using the five levels researcher designed rubric which was modeled after Bloom's Taxonomy for depth of knowledge. The effects of understanding learning include the preparation of lesson plans, classroom instruction, the guiding of student learning, and the professional development of teacher leaders.

Keywords: teacher training; measurement of learning
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INTRODUCTION

Learning is a term that is being used with great frequency in education and is a critical event today, because if a child has learned, then doors are opened to the world. However, if the student has not learned then their opportunities for success have been narrowed. Teachers are heard to say,

"My students learned their multiplication tables today."

This would be considered concrete and measurable, either they can recite them from

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memory or they can not.

"What is Learning?" It is no longer acceptable to say, "I know that the students are learning as they all are smiling and giving positive body language of acceptance during the lesson." This was at one time considered a "check for understanding" however, understanding is also a vague term which is not measurable unless on-going formative assessments are given by the teacher (Popham, 2008).

Schlecty (2002) identifies the behavior of smiling and nodding on the part of the teacher pleasing student as either

1) Ritual engagement, or
2) Passive compliance.

Can you "pass" a test and not have learned the information; is the "learning" only in short term memory to be dumped when the goal "passing the test" is achieved? This could lead to another discussion to be addressed at a different time.

It is critical for today's educators to be able to document a student's mathematical progress or lack of. Ron Edmonds (1979) believed that all students can learn. He based his life's work on learning trying to determine why in some schools all children were learning and in other schools, the same level of learning was not happening. There have always been pockets of schools "where learning occurred" and other similar schools where students were not learning as identified by state criteria.

Learning is defined in about as many ways as the number of people you ask. The dictionary thesaurus states that learning is knowledge, education, erudition, scholarship, understanding, research, study, teaching, instruction, edification and wisdom. The definition in the dictionary defines learning as acquiring of knowledge, acquired knowledge and change of knowledge. The term "learning" seems to float around teacher meetings, in-service and professional development training, the teachers lounge, parent-teacher conferences, university faculty meetings, and even in the classroom with the students. The term learning seems to be used in many cases to indicate a mastery of a concept, yet if a 'number of' or 'amount of' learning (a quantitative amount) had to be documented for any student, that amount would be a human guess, which maybe altered by the State to reach identified targets for learning for that year, that testing cycle. Learning in this context is not or has not been measured, when the targets for learning continue to move up and down based upon the scores of the students on the test. We are all familiar with movement of the learning—in the university classroom it is called a curve. The moving target that maybe unidentified leads to a vagueness or lack of clarity if we want to know "how much" or "what" did the student learn?

Learning by necessity in conversations about curriculum is generally connected to assessment in order to determine if learning has occurred. This "learning" becomes

critical for the classroom teacher. Popham (2008, p. 7) says,

> "...That formative assessment process must be based, not on a whim, but on evidence of the students' current level of mastery with respect to certain skills and bodies of knowledge."

This being the case, then the role of determining learning becomes the responsibility of the classroom teacher. When observing in classrooms, today, many of us have witnessed students being given a passing grade because they were compliant teacher pleasers, or a terrific problem that the teacher did not want to deal with again, they passed on to the next level of learning without understanding the "learning". Assessment did not occur and if it did, it was ignored. These children who have not learned and who have been passed from grade to grade experience the frustration and failure that accompanies, never learning.

Given the significance of high stakes testing that effects children and teacher's lives, it is no longer acceptable to say mathematical learning has occurred, when one child has been left behind. Learning must be measurable and real. It must last. Today educators need to be able to document a student's progress or lack there of and the interventions for learning are essential. Yet, is high stakes testing the answer for the dilemma of "learning." High stakes tests provide a framework for accountability. High stakes tests may serve to distribute teaching fairly and equitably for all students. Funding for schools is connected to learning or the lack thereof, but much more is learned in schools than can be measured on one test, on any given day of the week. The measurement for mathematical learning and of mathematical learning is critical to the life of the child. For the purposes of this work an attempt was made to determine a definition for learning based upon the understanding of teacher-candidates (pre-service students) and graduate students in the School of Education and Human Development in a regional institution that serves a predominately low income, rural, minority population. Additionally, this institution serves a large metropolitan area, which has a population that is diverse financially, ethnically, and culturally.

RESEARCH STUDY

This research study began as university faculty reviewed lesson plan assignments of teacher-candidates. It was found that an acceptable assessment/evaluation of the skill being addressed was missing in approximately 90% of the plans submitted. This seemed to be very odd that the students would just omitted one of the components of the lesson plans which they were developing even though it was listed in the assignment directions. In the directions, it was stated that all lesson plans must contain a title, objective/s,

supplies, procedure and assessment/evaluation which matches the objective/s.

Lesson plans do serve as data source for a qualitative assessment of learning as university faculty members review and evaluate lessons submitted... (Groth, Spinkler, Bergner, & Bardzell, 2010). In their lesson plans, the students often used terms such as the student will learn or the student will know. When 'learning' was used it was vague and never in a context which could be measured.

It was noted that most of the math lessons which were missing components cited an online source for his/her lesson. In her work, Patton (2009) found that many of the lesson plans on the Internet were not quality. Using the same very basic components, she found that less than 10% were complete. She did not do any judgment as to the quality of the component; it was a simple response of yes if the component was there and no if it was not. The study evaluated approximately 200 lesson plans which were retrieved from the Internet when using a basic search. These lesson plans were picked randomly after an internet search was done to locate the various sites. Only one lesson plan was printed from each site to be included in the study. All the lesson plans in her study were grades 3-6 math. As a result of this work, Patton began to wonder if students really knew what it meant when they had in a lesson plan evaluation that a student had learned the objective. Not only was it vague in the lesson plans but very few could document that learning had taken place.

Further in an informal conversation with a graduate faculty member, it was determined that it was not just an undergraduate problem but one which spans both undergraduate and graduate students. This graduate faculty member teaches "learning" for teachers becoming principals. The graduate students had several class sessions spent on "learning." What is learning and when has learning occurred? Again, the responses were vague, non-specific and general, without the extended focus and discussion on learning, there was no real determination of "learning" by prospective principal students. The conceptual framework for this study was based upon the importance of understanding learning indeed, what is learning, when has he student passed into the learning threshold?. The grounding for the theory was that education students would be able to write an over-view of what they considered to be learning which would apply to the classroom as teachers are expected to evaluate learning both from a formative perspective and a summative standard. The researchers realized that this study was not a research study which would reveal absolute answers; it does give an indication of the perception of learning or lack thereof by under-graduates teacher education students and graduate education students/This study does give the perceived definition of 105 students enrolled in undergraduate education or graduate principalship classes. Thus with this in mind educators might become more aware that not everyone defines "learning" in the same manner. It is most important that educators do not make the assumption that everyone defines it the same if

they are to truly going to prepare their students for the future. This study just emphasized that the perceived definition is very complex and must not be taken out of context if we are going to have the meaning. The sampling was all of the students enrolled in field based teacher internship and the introduction to Education Leadership Master's course.

PURPOSE

The purpose of this study was to determine what undergraduate and graduate students in the School of Education and Human Development consider to be "learning." That is: The researchers for this project were attempting to determine how others describe and interpret learning. The overarching question to be answered was: what is the level of student understanding based on 'Learning' upon Bloom's Taxonomy." This research effort is evolving from the original question of "What is Learning?" and the lack of clarity of the responses given by the students.

METHODOLOGY

The subjects of the study were 105 teacher-candidates and graduate students preparing for the principalship. There were 51 teacher-candidates and 54 graduate students. These students were surveyed to determine how or what they perceive as mathematical learning. The teacher-candidates are in the last semester of coursework before doing student teaching. These teacher-candidates have been busy preparing lesson plans and were asked as a part of a multiple phased assignment to give their personal meaning of mathematical learning. In an additional, second assignment, they were asked to write a paper on learning and to state how they could document a student's progress. Mathematical learning will be addressed in this paper. The future principals were given the same assignments; we must remember that these graduate students are in the classrooms, thus preparing lesson plans on a daily basis. "Does a new mental model need to be developed for the teacher-candidates and future aspiring administrative leaders?" is a question which seems to appear repeatedly as this work is addressed.

This was a pilot study and the subjects were students in the researchers' classes. All the students in the specific undergraduate class were included in the study. All the graduate students enrolled in the principalship classes were also included. Each of the classes is a required class in their respective programs.

The ethnicity of the students in this study is very diverse. Approximately 50% of the student body is majority and the other 50% are minorities including about 4% interna-

tional students. The ethnicity of the students in this study matches that of the student body of the University.

The ages of the students were very typical of the university student body. The undergraduates were mostly female and approximately 28–32 years of age. The graduate students are generally a few years older (about 5–7) and in about equal numbers of males and females.

INSTRUMENTS

Survey A: Quick 3–4 minute response to the question "what is learning"?

Level 5					Gained information, able to apply and then have that information which was gained measured in some way
Level 4				Gained information, complex definition and the person is able to apply what was gained.	
Level 3			A detailed definition however is just banking the information and is not able to apply the gained knowledge		
Level 2		Is able to give an answer however, is not able to do more than bank the information.			
Level 1	Lowest of levels. Only repeat the word, learning; does not give an answer or defines learning with learning. This one is almost lower than the knowledge level on Bloom's taxonomy. ©patton, 2009				

Figure 1. Researcher-designed Rubric of the Levels of Learning

Several weeks prior to the survey being distributed, the researchers developed a hierarchical, five-tier ranking system to evaluate the surveys. Bloom's taxonomy served as a model of hierarchical ranking to evaluate the surveys. The work of Randall Charles (cf. Charles, 1985; Charles *et. al.*, 1986; 1989) with mathematical problem solving was also an influence.

The participants in the survey were asked to write their definition of learning. They were given about 3 minutes to do so. They were told well in advance that the task was not a graded exercise as to the quality. It was either a full credit if you participated or no-credit if you did not. It was hoped that this would relieve some anxiety and allow the participants to elaborate on the task. Both groups of students breathed deeply and hesitated to respond to the quarry, however, after a couple of moments were hard at work. The survey was given as a method to discover the perceptions which students had about the term 'learning'. Learning seems to be almost a loose term which takes on many different

meanings according to the context the speaker desires. It is desired in a full study that the students would be able to have some type of intervention after the initial survey and then a post test would be given. However, in this pilot type test it was not possible due to time constraints.

After the surveys were completed the responses were first coded into two categories. The first being very simply responses and in the other the responses were more complex. Next the responses were evaluated using a researcher-designed rubric which was modeled from the very low knowledge level response to the highest level which utilized a judgment and evaluation in the explanation. By using this system, each researcher had multi-evaluations of each survey and on the second evaluation; it was not unusual for the research to move a survey to a different level.

The two researchers rated the surveys individually and then met and re-evaluated each. The ratings of the two researchers were very close. When there was an evaluation not in agreement, the two discussed and came to a consensus. Using the criteria there was 95% agreement, thus establishing inter-rater reliability.

Responses to the surveys were scored using the rubric to measure levels of thinking. The grading rubric was a 1–5 Lickert scale. The responses which only had a few words and repeated the word 'learn' or used the word 'learn' to complete the definition were rated a one (1). A rating of a two (2) was reserved for definitions which were of very low level and seemed to believe that the human mind was a bank for the information and was not be used. It was to be stored or banked. This banking was more like a safe deposit box where the info was safe but did not gain any interest or in this case no new information could be added. The ranking of a three (3) was given for a more detailed definition and possibly even added a little information but it was still kept in the safety of the bank. For a four (4) the response illustrated that the person gained the information and was able to apply and use it in a constructive manner. The highest tier on the hierarchical chart was a five (5). In this highest ranking the students illustrated gained information, which he/she was able to apply and then have that application measured or evaluated in some manner.

RESULTS AND FINDINGS

For the purpose of the findings to the question "What is mathematical learning?", only one student, a teacher candidate, 1 of 51 responded at the lowest level. None of the graduate student responses were evaluated on the Patton Evaluation Instrument as a Level One response, meaning they only repeated the word or words mathematical and learning and did not give an evaluation or an answer to define learning.

The undergraduate response at Level One on the Patton Evaluation Instrument was:

Learning is the process of knowing something. Someone might not learn something immediately. The process might have to be reviewed but eventually learning will take place."

Fourteen of 51 teacher-candidates (27%) responses, were at Level Two on the Patton Evaluation Instrument as did 11 of 53 graduate students (21%). By a Level Two response, they were considered to have given an answer to what is learning, but they did not apply or evaluate learning as apart of the response. An example of Level Two response at the undergraduate level is: "Learning is a cognitive change. This may be done through neuro-sensory input, implanted in brain cells and retrieved." An example at the graduate level is: "Learning can be defined in so many different ways. Learning is a depth that is achieved through knowledge and adequate study. It is also a means of progress."

Twenty-three of 51 teacher-candidates (45%) of the responses were a Level Three on the Patton Evaluation Instrument. A detailed definition was provided, but there was no application indicated in the response. While 20 of 53 graduate students (38%) responses were rated as a Level Three. An example of an undergraduate response of Level Three is, "Learning is knowledge based comprehension strategy that is gained through out a lifetime in an effective environment. If not utilizing the cognitive thinking and modeling that becomes repetitive in its process, it can quickly get lost." An example of a Level Three Graduate response is:

Thirteen of 51 teacher-candidates' responses (26%) were a Level Four on the Patton Evaluation Instrument. They gained the information and provided a complex definition which included application. Seventeen of 53 teacher-candidates' responses (32%) were rated as level four. An example of an undergraduate response at the Level Four is: Learning is the skill of acquiring information or knows how of something you did not have before. The true form of learning is to be able to take what you have learned and not only apply it, but teach it to others." An example of a graduate Level Four response Learning is when you can show what has been taught. It is being able to teach someone a concept you have been taught. Learning is doing, showing and demonstrating. Learning is fun!"

While 5 of 53 graduate students (9%) had a Level Five response on the Patton Evaluation Instrument. There were no Level Five responses from the teacher-candidates. Level Five is the highest of levels and most difficult to achieve. To be rated a Level Five response the answer to "What is learning?" encompassed the lower levels of knowledge, application, and added the element of evaluation, the responder could document the "mathematical learning" results. An example of the Level Five responses at the graduate level is: "Learning is what information you should know and way you should be able to do with the information. Learning is taking relevant information and being able to apply it in context and in a meaningful situation. It is the process by which, when applied, a desired outcome occurs. Student 101)" There were no Level Five responses from the

undergraduate students.

See Table 1 below for these findings.

Table 1. Numbers of responses at each level of the rubric

	Teacher-candidates	Graduate Students
Level 1	0	5
Level 2	13	17
Level 3	23	20
Level 4	14	11
Level 5	0	1

A graph comparing the teacher-candidates and graduate students at each level of the rubric is shown below.

The overarching question to be answered was: what is the level of student understanding based on 'Learning' upon Bloom's Taxonomy." This research effort is evolving from the original question of: What is Learning?" and the lack of clarity of the responses given by the students.

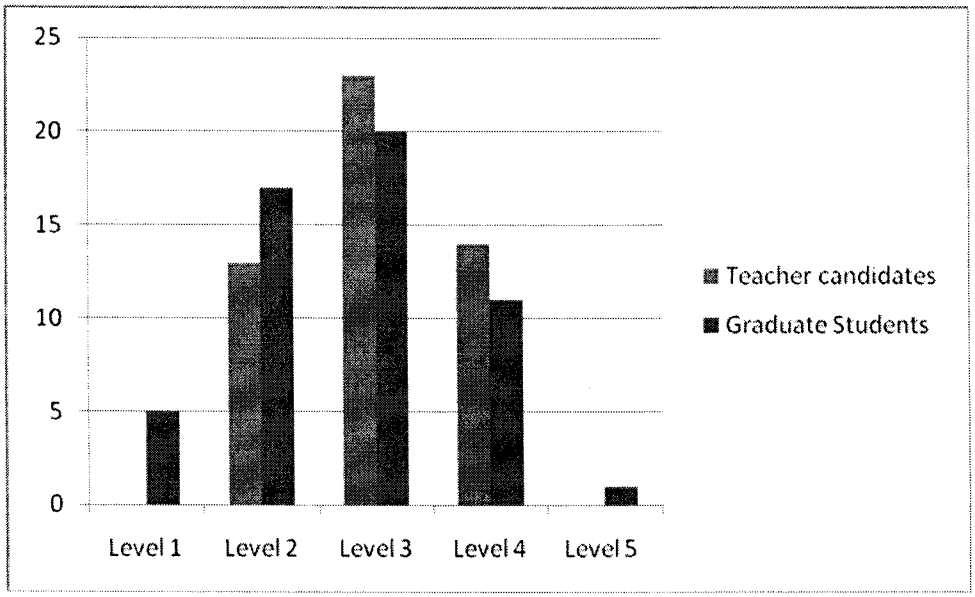

Figure 2. A Comparison of Responses at Each Level

IMPLICATIONS

Do we as educators need to change the language of the education community? The answer is a definite yes if we are going to document a number which can and does open and close doors for students? Students are allowed in programs where they really do not have the background knowledge or even need in those particular programs. By the same token, students are refused entrance into programs as they did not empress certain adults who are making the call, yet if given a measurable instrument, these students prove to be very proficient in the topic. Further, as Educators we need to define, "what is mathematical learning?" so that teachers and principals can focus upon the importance of the mathematical learning in the classroom.

A new term needs to be coined that can describe to the world of education and to the larger community, what is implied when it is said that, one has learned mathematics. Did they master the mathematical concept; will they remember the learning six months or five years from now? Or, did the student only learn the mathematics to pass a test and then forget the information to go on to a new 'learning.' The new term needs to be one that is measurable, can be documented, described and explained, have a common meaning so that everyone, including all ethnic groups, will have a fair chance when it is used.

If learning is a process rather than a test as suggested by Popham, then clarity is required when the use of the term is applied. Curricular aims need to be determined. Subskills leading to mathematical learning should be identified and our own beliefs about learning must be clear (Popham, 2008; Lambert, 2002; Schlecty, 2002).

This is exemplified when a young teacher moves conceptually into understanding a mathematical concept that she herself had never grasp, until reflecting with her learning community (Yarema, Smith & Hutto, 2010). The teacher learning example is a problem for the 5th–6th grade research lesson in mathematics which was stated as follows:

"A new season of sports has started and programs are being designed for printing. Certain companies purchased spaces on your 8½ inch by 11 inch rectangular advertisement page to be seen in the next program. Given the ad pieces, your group must design an advertisement page for the program. You will notice that ads are in three categories: entertainment, apparel and food. What fraction of the page is covered by entertainment ads?"

Students were introduced to advertising by perusing sports programs, and then the teacher posed the problem and gave each group of student's materials for designing an ad page using 8 separate ads with different areas. Out of the 8 ad pieces, three fell into the category of entertainment. After some difficulty with designing an ad page, all groups stated the answer to the problem as 3/8. Although this answer was anticipated by the

teacher's lesson study group, the teacher became disturbed that all students "got the wrong answer. From the front of the room, she then directed students through a paper folding exercise, folding the advertisement page into halves, fourths, and eighths. At that point, she asked students to place the 3 entertainment ads on the page. Following this set of instructions, students saw that 3/8 of the page was not covered, and some changed their answer accordingly to (3 ½)/8. Although this answer is technically correct, the teacher did not see this as a possible answer and instructed students to fold the paper again into sixteenths, thus leading all students through the same solution process to the answer 7/16.

During the post lesson discussion with the observers, teacher learning was identified; the teacher elaborated on the decision made as an individual teacher. Then the group moderator called on various people to ask the teacher questions. A teacher colleague asked her how she thought her students would have responded if she had focused them on the whole to the fraction in the problem. The teacher referred back to a mathematics lesson in a summer professional development that she had attended, and she state, "that she never thought in terms of the whole to the faction." Then the teacher's principal complimented her on introducing the paper folding exercise and asked her the reason she chose to continue folding the paper to sixteenths. The teacher admitted that she did not know what to do when all the students answered 3/8 and that her pedagogical choice of folding the paper into sixteenths took away the opportunity for students to engage in problem solving as it led them all to the same answer of 7/16. She also stated that she did not know if they understood this answer. Next, the outreach mathematician asked her why she redirected students away from the answer [(3 ½) / 8] of the page being covered by entertainment ads. The teacher was unable to respond as other teachers from her school commented about the need to hear students' explanations so the group could learn more about what students were thinking. During this discussion, another teacher commented that she finally understood why [(3 ½) /8] of the page is a correct answer. The teacher then reiterated what she had learned from the debriefing. The question evolves again, when has mathematical learning occur? Is it incremental, in stages as concepts develop both for students and teachers?

Benjamin Bloom understands the responsibility of the teacher in the classroom for student learning. He states that students, maybe different in the rate that they learn, but not their potential for learning (Bloom, 1981). Other factors can be identified that effect and influence the learning of mathematics. One of the primary factors effecting student learning is the effectiveness of the teacher (Podesta, 2000). Studies have shown that students with teachers who are highly effective out perform other students on standardized tests. The expert teacher work can be very different from that of the novice teacher. The implications for the mathematical learning of the student are significant. Learning is required. While there are graduations in teacher mathematical content knowledge and

pedagogy, there still should remain a sense in all teachers in every mathematical classroom. What is learning for that day? Bransford & Vye (1989, p. 193) cite the variations in knowledge from "know that, something is true to 'knowing how' to think, learn, and solve problems."

It is imperative that educators realize that "Learning" does not have a single definition. In turn educators must be sure that everyone at any given situation using the term is defining "Learning" in the same way if the collective group is to be successful. Teachers must know (be able to document) if a student is successful or not, if that teacher is going to be able to make sure that each and every student reaches his/her potential. The stakeholders of today's educational society demand to see documented evidence that the students are learning and mastering the required content. Each school, public and private, answers to a higher entity who in turn reports to the State and ultimately the Federal government the level of learning of the students. Reports *i.e.*, STEM, etc. keep the progress or lack of learning in the public eye. The effectiveness of the schools is closely monitored. The level of learning of the students is monitored by the government, business, parents, and tax payers as they determine whether or not families will choose to move to a town, a neighborhood, or a state. Internationally the educational level of each and every country is compared daily to determine the intellectual capacity of the citizenry.

CONCLUSIONS

If, as a global society, we are using high stakes testing to determine if students are learning, then the teacher should be able to state the learning goal and know the scaffolding steps that would lead to the learning goal. What is learning, when did it happen, or if the student did not learn, then what action did the teacher take to re-teach, re-mediate so that the student did learn. Are there learning progressions-scaffolds and have they been identified, in order for the student to learn the larger concept of the lesson. Deep and important discussion should be a part of the teacher education curriculum that include what is learning, when did learning occur, did the information pass the attention threshold for the student, is it stored in long term memory. How do we encourage students to learn? Each teacher must be able to identify the timeline for that individual student learning has taken place and for her/him and what is learning for that individual lesson, concept, unit, or area of study. While it is impossible to know everything in today's society, it is critical that educators understand learning, in order to assure that all students do learn.

Connecting teacher learning with student learning is the theme of the ten key principles of professional development as outlined by Timperly (2008), whereby experts work with teachers to assist them as expert teachers who teach others content and skills of

pedagogy. Focusing upon student learning whether in the K–12 classroom or the university setting becomes a priority, if all students are going to "learn." Additionally, the professional development of teachers to extend and scaffold content knowledge become an important role of school districts and universities as they reach out and build learning communities. Newmann & Wehlage (1995, p.3) noted that "Schools with strong professional communities were better able to offer authentic pedagogy and were more effective in promoting student learning".

It is significant that learning can be documented as mastered. In the math world, if teachers are not able to document a student's progress, they are not able to focus on the needs of the students. The documentation of skills or verifying learning is essential if a teacher is going to provide math instruction as a continuum. Math concept when mastered can be scaffold from the easiest to the most difficult. While not every single math concept is built on others, the student must be provided the opportunity to have this scaffolding if he/she is going to be successful in all higher or more advanced math. An example of something is a student does not have to know basic computation to identify geometric shapes however, if two interior angles of a triangle are given that student must be to do basic computation to find the number of degrees in that third angle.

The next area for research will be for the teachers to identify their learning goals with measurable objectives for their students and then determine, if learning has occurred. Without the use of measurable objectives, it is impossible for a teacher to be able to document students' mastery or lack of.

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