# THE FORMATION OF MATHEMATICS CURRICULUM CHARACTERISTICS BY AUGUSTUS DE MORGAN IN UNIVERSITY COLLEGE, LONDON

## On the Boundary between Mathematics and Natural philosophy

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**ABSTRACT**

In the early nineteenth century, mathematics professors did not teach the same areas of mathematics in various institutions. The boundary problem between the adjacent fields and the institutional matters could be important in the constitution of the different educational curriculums. This article examines the important factors which had influence on the constitution of mathematical curriculums in UCL. So this research will then suggest that for the better understanding of a mathematician, it is necessary to investigate the systematic nature of the institution in which the mathematician worked at, the nature of the students who that mathematician taught, the mutual relationships between the other professors of the adjacent areas in the same institution, and the distinctive educational features of the adjacent areas in that institution.

**Keywords:** Augustus De Morgan; Dionysius Lardner; pure mathematics; mixed mathematics natural philosophy; experimental philosophy; boundary between adjacent areas; curriculum; University College, London

## 1 Introduction

Until the mid-seventeenth century, the status of mathematics was considered rather low comparing with that of natural philosophy, and the boundary between them was relatively clear. Natural philosophy was the field which studies about the natural reality and explores the cause of the natural phenomena while mathematics was the field which attends to ideal objects and seeks to save the phenomena.[1] The proper developments of mathematical tools and experimental instruments were necessary for the boundary change besides the problems of epistemological status of mathematical representation and truthfulness of the results by experiments.

With the success of Issac Newton, the attempt to describe and analyze the natural phenomena and the motion of natural bodies mathematically came to gain credibility, and the trial was expanded

[1] Peter Dear, *Discipline & Experience: The Mathematical Way in the Scientific Revolution* (Chicago: University of Chicago Press, 1995), pp. 35–46, 161–168.

into the other areas of natural and experimental philosophy.[2] Especially, the French scholars' contribution was successful in those attempts[3] and so the range of mathematics became very wide from elementary mathematics to advanced mathematical physics parts in the late $18^{th}$ century. And the boundary between mathematics and natural philosophy was very vague since then. This disposition continued until early $19^{th}$ century. An example of which was in 1814, English mathematician Charles Butler classified mathematics as pure and mixed mathematics in his book, *An Easy Introduction to the Mathematics*. The former included arithmetic, geometry, differential and integral calculus, and analysis. And the latter encompassed the mathematical physics parts like astronomy, optics, mechanics, hydrodynamics, and pneumatics, and the practical parts such as acoustics, surveying, architecture, navigation, pyrotechnia, chemistry, and electricity.[4] Then, what was the mathematics curriculum of various universities in the early $19^{th}$ century England?

This article will focus on the first mathematics professor, Augustus De Morgan(1806–1871), in the newly established university in 1920s, University College, London (UCL)[5] to examine the academic boundary surrounding mathematics in the early $19^{th}$ century. Boundary problem was not acute in the traditional institutions like Oxford or Cambridge compared to the new university because teaching students was not an important duty of professors in the traditional university and so the already employed professors studied on the areas of their interest regardless of the boundaries of adjacent disciplines. On the contrary, it had to be newly done to subdivide academic disciplines, to name each professorship, and to decide teaching areas and curriculums in the new college. Thus, UCL can be helpful in understanding the change of contemporary academic situation surrounding mathematics and the process of drawing boundaries between adjacent areas.

## 2 Augustus De Morgan's Pure Mathematics Curriculum

From the beginning, UCL adopted a professor-teaching system in contrast with Oxford and Cambridge University. Thus teaching students was the most important duty of professors in UCL, and so the class courses and curriculums had to be properly planned. Directly after the appointment on $23^{th}$ February, 1828, De Morgan drew up a mathematics curriculum and the curriculum was inserted in the *Second Statement by the Council of the University of London, Explanatory of the Plan of Instruction* which was printed in June 1828. Considering the facts that he was only 21 years old, just graduated from Cambridge University, and the *Second Statement* was printed right after his belated appointment, we can assume that his curriculum would be very similar with that of Cambridge University and that the curriculum would include from the pure mathematics to the mixed mathematics parts.

However, his curriculum was organized with mainly pure mathematics parts. His mathematics classes were composed of 2 years courses, a lower and a higher division. According to the *Second Statement* of 1828, during his first year, he mainly taught arithmetic, algebra, the plane, solid and descriptive geometry, and the plane and spherical trigonometry. The second year's course embraced

[2]Thomas Kuhn, "Mathematical versus Experimental Traditions in the Development of Physical Science", *Journal of Interdisciplinary History* 7 (1976), pp. 1–31.

[3]E. Garber, *The Language of Physics: The Calculus and the Development of Theoretical Physics in Europe, 1750–1914* (Boston: Birkhäuser, 1999), pp. 31–34, 78–86.

[4]Charles Butler, *An Easy Introduction to the Mathematics* (Oxford: Bartlett and Newman, 1814), vol. 1., pp. xxxi–xxii.

[5]UCL was established as 'London University' in 1826. However the name was changed into 'University College, London' when 'University of London' was newly established in 1836 as the administrative institution for the colleges in London.

the field like conic sections, transcendental algebra, trigonometric analysis, algebraic geometry, calculus, the theory of projection, and probability.[6] Over time, his teaching areas were confined to pure mathematics. For example, in the London University Calendar of 1831, the theory of projection and probability were excluded in the curriculum.[7] Later on, his students also remembered him as a pure mathematics professor.[8] In addition, his professorship was regarded as the pure mathematics position. When natural philosophy professor, Richard Potter, retired from the office in 1865, his professorship was divided into two professorships: 'Mathematical Physics' and 'Experimental Physics'. For Mathematical Physics, Thomas A. Hirst was employed. However, the name of Hirst's professorship was changed into 'Pure and Applied Mathematics' when De Morgan resigned from his position in 1867.[9] Considering that both mathematical physics and applied mathematics were used to signify the same academic areas, the change of the name of Hirst's professorship means that the mathematical realms of De Morgan were thought of as pure mathematics.

De Morgan's pure mathematics curriculum was a very peculiar one in comparison with the curriculum of the other universities or colleges. The traditional Cambridge and Oxford Universities had taught the wide range of mathematics parts from pure to mixed mathematics.[10] This way was applied to the Military academy or colleges like Royal Military Academy, Woolwich and Royal Military College too.[11] Then was the pure mathematics curriculum a distinguishing feature in the new universities of London? For this, it is necessary to investigate the curriculum of King's College, London (KCL) which was a very similar institution with UCL. The first mathematics professor of KCL was Thomas G. Hall(1803–1845). He graduated from Cambridge University as $5^{th}$ wrangler in 1824 and also applied to the mathematics professorships of UCL before De Morgan. Hall could not be the first mathematics professor in UCL because he withdrew his application for a religious cause, but he was an excellent mathematician.[12] However, when Hall was appointed in KCL, his curriculum was very different with De Morgan's.

Hall included mixed mathematics parts including pure mathematics in his curriculum. His classes were composed of 3 years courses. For the first year, he taught arithmetic, geometry, algebra, plane trigonometry, logarithm, conic sections, and the chief propositions in mechanics. The next year, he introduced the first three sections of Newton's *Principia* with the higher parts of algebra, the theory of equations, the application of algebra to geometry, and differential and integral calculus which would enable students to comprehend those theoretical parts of mechanics. For the final year, his teaching

[6]London University, *Second Statement by the Council of the University of London, Explanatory of the Plan of Instruction*, (London: John Taylor, 1828), pp. 42–45

[7] London University, *The London University Calendar of 1831* (London: John Taylor, 1831), pp. 53–57.

[8]Mr. Taylor recollected his old teacher as a pure mathematics professor in the *Cambridge University Reporter*. "As Professor of Pure Mathematics at University College, London, De Morgan regularly delivered four courses of lectures,⋯and His course embraced a systematic view of the whole field of Pure Mathematics, from the book of Euclid and Elementary Arithmetic up to the Calculus of Variations.", Sophia De Morgan, *Memoir of Augustus De Morgan* (London: Longman, 1882), pp. 98–99.

[9]H. Bellot, "Chart 4. Growth of University of London, University College from 1826 to 1926, Faculty of Science" in *University College London 1826–1926* (London: University of London Press, 1929)

[10] For the curriculum of Cambridge University, Rouse Ball, *A History of the Study of Mathematics at Cambridge* (Martino Publishing, 2004), pp. 190–192.; John Wright, *Alma Mater, or, Seven Years at the University of Cambridge* (London: Black Young, and Young, 1827), Vol. 1, p. 9, 206, 207, 225–226, Vol. 2, pp. 25–29, 15–58.; For Oxford University, the following document can be helpful, Anonymous, "On University of Education-Oxford", *Quarterly Journal of Education* 2 (1831), pp. 23–29.

[11]Niccolo Guicciardini, *The Development of Newtonian Calculus in Britain, 1700–1800* (Cambridge: Cambridge University Press, 1989), pp. 108–123.; Charles Hutton, *A Course of Mathematics* (London: F.C.&J. Rivington, 1811), 3 vols.

[12]Adrian Rice, "Inspiration or Desperation? Augustus De Morgan's Appointment to the Chair of Mathematics at London University in 1828", *The British Journal for the History of Science* 30 (1997), pp. 261, 264.

areas were composed with spherical and solid trigonometry, the higher parts of the differential calculus, physical astronomy, the theory of the earth, and the analytic parts of hydrostatics, optics, and astronomy.[13] The areas which Hall taught in his class were very wide, and similar with the Cambridge University. So the numbers of the students who studied with Hall, and then went to the Cambridge University for the advanced study were many, and their scores in the Mathematical Tripos of the Cambridge University were very high.[14]

## 3 Why Did De Morgan Teach Only Pure Mathematics?: The Boundary Problem Between Mathematics and Natural Philosophy

Why did De Morgan teach only pure mathematics parts in his classes? It is safe to say that studying in the Cambridge University didn't seem to affect his teaching because his curriculum was different from the professors who came from the same University. Then did he have an ardent interest on pure mathematics parts? The memoirs of De Morgan by his wife shows that he has more interest on mixed mathematics or mathematical physics fields than pure mathematics parts.[15] Then did he not possess the sufficient mathematical ability to teach the advanced mixed mathematics parts? Considering the testimony of his teachers and the contract for Statics text with SDUK (Society for Diffusion of Useful Knowledge), he had excellent knowledge about mixed mathematics.[16]

And so, did UCL committee not intend to provide mixed mathematics? For this, we have to examine in detail the process of the employment of De Morgan. In the earlier time, UCL had planned two mathematics professorships, 'Elementary Mathematics' and 'Higher Mathematics and Mathematical Physics'. For the latter position, UCL committee tried to employ Charles Babbage.[17] When Babbage did not accept the proposal, Dionysius Lardner(1793–1859) applied for the two mathematics professorships. However UCL suggested natural philosophy professorship to Lardner. After Lardner was appointed as 'Natural Philosophy and Astronomy' professor, the name of Higher Mathematics and Mathematical Physics professorships were changed into 'Higher Mathematics'.[18] And then UCL committee secretly contacted John Herschel for the Higher Mathematics professorship.[19] De Morgan was selected by UCL after Herschel politely refused this position and Higher Mathematics professorship was united with Elementary Mathematics professorship into just one 'Mathematics' professorship. For what UCL intended for Mathematics professor, we have to think what 'higher mathematics' meant back then. If higher mathematics meant higher pure mathematics areas, it is difficult to explain how UCL committee could propose pure mathematics position to the noted astronomer, John Herschel. Thus if we regard higher mathematics as mixed mathematics, then De Morgan's curriculum had nothing to do with his intent and ability, and the UCL's plan. In the end, we have to find the different factors of the pure mathematics curriculum of De Morgan in UCL. Then social, institutional, economic, and interdisciplinary point of view can help to understand another side surrounding the

[13]King's College, London, *Calendar of King's College, London, for 1833–34* (London: John W. Parke, 1834), p. 14.
[14]Rice, "Mathematics in the Metropolis: A Survey of Victorian London", *Historia Mathematica* 23 (1996), p. 390.
[15]S. De Morgan, *Memoir*, pp. 18, 24.
[16]S. De Morgan, *Memoir*, pp. 19, 28, 41–69.; Rice, "Inspiration or Despertion?", pp. 268–271.
[17]Rice, "Inspiration or Despertion?", p. 266.
[18]London University, *Statement by the Council of the University of London, Explanatory of the Nature and Objects of the Institution* (London: Longman, 1827), p. 10.
[19]Rice, "Inspiration or Despertion?", pp. 66–68.

constitution of the curriculums.

The Boundary between mathematics and natural philosophy was not clear in the 1820, 30s. The way of defining each discipline was different and the terms were not consolidated. On one hand mathematical physics parts were called mathematics, and the other natural philosophy. So it was difficult to divide the boundaries between mathematics and natural philosophy. However ordinary scholars did not mind dividing the academic boundary and just continued their study depending on their own interests. There was no classification between academic journals or societies which were used for publication or presentation of the research about mathematics and natural philosophy.

However, the boundary problem could be very acute in UCL. UCL had to start the whole things afresh but could not get any support from the government because of its secular nature. Fund was not enough. Given these circumstances, the wages of professors were determined in proportion to the fees of students in classes. Then it could be an important matter for professors to secure the wider areas for their curriculum and sufficient attendees. Thus drawing boundary could be a more sensitive problem between the professors of adjacent fields in UCL.

Under this circumstance, Lardner was employed as the first natural philosophy professor in UCL. Lardner was a very attractive scholar considering the current academic state of UCL. He had frequently contributed to the very popular journals like *Edinburgh Review* and *Metropolitan Cyclopaedias*, published a lot of mathematics textbooks including *The Differential and Integral Calculus*, and had outstanding skill in popular lecture to take the gold medal from Dublin Royal Society for the lecture about steam engine.[20] So UCL committee persuaded Lardner into getting natural philosophy professorship, although he had applied for the professorships of Elementary Mathematics, and Higher Mathematics and Mathematical Physics first of all.

But Lardner did not immediately accept the natural philosophy professorship. Natural philosophy was considered to be more noble discipline than mathematics, but teaching natural philosophy in UCL was a different problem with the academic status. The regular natural philosophy class was permitted for the students who had sufficient knowledge of mathematics. However the educational level of the UCL students was not good because the situation of mathematics education at elementary and middle levels was very poor in the early $19^{th}$ century London. That meant the number of students who would attend the natural philosophy classes might be small, and it could be connected with the poor wage.

So Lardner requested an exact explanation about his salary and the terms of his employment when he got the proposal for natural philosophy professor through Henry Brougham who was the principal member of the UCL committee. With his request, Brougham sent the following letter in May $24^{th}$, 1827.

> "The class you will teach cannot be of less value than 1200*l*. a year. Our plan prevents us from securing a salary larger than 300*l*.; but there will be pupils to pay five or six guineas each, say six for two courses of six or three months; and I look to three hundred pupils as the very last number which may be expected.[21]
>
> It is probable that five hundred will attend the Experimental Philosophy and higher mathemat-

[20] James McMullen Rigg, "Lardner, Dionysius", *Dictionary of National Biography, 1885–1900*, vol. 32, pp. 145–147.

[21] John Conolly et al., *Statements Respecting the University of London, Prepared, at the Desire of the Council, by Nine of the Professors* (London, 1830), p. 20.

> ical physics, and that a junction could be in effect of yourself with some popular experimental lecturer, securing to you two thirds of the profits, which leave 2000*l*. for you, and 1200*l*. or 1500*l*. for him."[22]

This letter meant that experimental philosophy and higher mathematical physics would be Lardner's share. After this letter, Lardner included both mixed mathematics and experimental philosophy in his natural philosophy curriculum. He showed his viewpoint about the boundary of natural philosophy in the first lecture of $28^{th}$ October 1828. He divided natural philosophy into mechanical philosophy and chemical philosophy, and put the mechanical philosophy between pure mathematics and chemistry. And then he defended natural philosophy from the criticism against it through confronting natural philosophy with not just mathematics but pure mathematics. For him, even experimental philosophy parts like electricity were one of mixed mathematics, and mixed mathematics was the branch of natural philosophy.[23] After then, his regular classes were planned with the high standard, and were permitted only for students who "attended the lectures of the Mathematics professor during the first session" or already possessed "a sufficient knowledge of the elements of mathematics science to enable them to join" his class.[24]

In this situation, the young De Morgan could not teach the same mixed mathematics areas in his class. Lardner was his senior and a revered scholar in academic world. By comparison, De Morgan was very young and had no academic career besides the $4^{th}$ wrangler of the Cambridge University. And Lardner was employed earlier than De Morgan by nearly six months. This meant that Lardner had been planning his classes when De Morgan was just employed. In the fee-related salary system, it was not easy for the young professor to have the lecture area which senior professor already held, and to overlap the curriculum of the adjacent fields.

In addition, Lardner had difficulty in maintaining a sufficient salary although he had preoccupied the whole mixed mathematics parts. At first, Brougham made Lardner feel at ease about his salary promising a considerable sum of money, but it was not official. So Lardner asked for the mediation about his salary problem to Leonard Horner who was employed as the Warden of UCL. However LCL did not pay the wage, 300 pounds, to Lardner in the first session and the student fees were also decreased to 4.10 pounds per class, when UCL actually opened the courses.[25] Lardner began to convey the contents of the engagement with Brougham to the UCL committee through Horner. However, Horner did not report the matter to the committee well. On the $20^{th}$ June, 1829, the answer which Lardner received through Horner was that UCL committee determined to allow him "a salary of 300 pounds for the first two years that is, until the $1^{st}$ of November, 1830, but not longer, and refused to allow the stipulated fee."[26] Lardner objected to this decision at once and demanded for reconsideration. But the Council declined his request. And then he was notified that no money would be paid to him, unless he would sign a legal defeasance of his claims under the original agreement. He could not but subscribe to the document prepared by the UCL Council. His salary was, however, not regularly paid even after then. He continuously sent the letters for the delivery of his discontent and

[22]Conolly et al., *Statements Respecting the University of London*, p. 23.

[23]Lardner, *A Discourse on the Advantages of Natural Philosophy and Astronomy, As Part of a General and Professional Education, Being and Introductory Lecture Delivered in the University of London, On the $28^{th}$ October, 1828*, (London: John Taylor, 1829), pp. 8–16.

[24]London University, *Second Statement*, p. 46, 52–63.

[25]Conolly et al., *Statements Respecting the University of London*, p. 25.

[26]Conolly et al., *Statements Respecting the University of London*, pp. 33–34.

the amicable settlement of wage problem to the UCL Council. After that, the UCL committee planned the arrangements for remunerating to, at least, a certain extent nearly all the professors for the next session, but made an exception of Lardner. And the problem of expulsion was also mentioned in the process of discussion about salary.[27]

Although ULC concerned natural philosophy in the early stages, the condition surrounding natural philosophy was poor. Natural philosophy lectures were located on the higher stages in the whole educational course. There was little inducement for studying natural philosophy in UCL. For the most part, UCL students had much interest on the professional discipline like law or medicine. And many students in UCL were non Anglican, and had difficulty in going on to Cambridge University which gave the first rate mathematics education.[28]

While Lardner had trouble with his salary, De Morgan felt tired because of the overflowing of students. For the first session, the students present at his lecture class were above one hundred. And the number of the students increased on the following sessions.[29] In these situations, he had no choice but to adjust his curriculums not to overlap with Lardner's.

## 4 The Educational Impact of the Teaching style of Certain Area on the Adjacent Areas

In the early nineteenth century, the teaching condition surrounding mathematical sciences was very poor. Considering the religious leanings or vocational aptitudes, the students who would have interest on mathematical natural philosophy were not many. In that time, the evaluation on mathematical sciences was negative and the popular experimental lectures made public to regard mathematical approach more difficult and unnecessary through experimental demonstration with interesting instruments or mechanical models.[30]

So, independently of the regular courses of mathematical natural philosophy, Lardner was concerned about the preparation for popular and experimental lectures for the student who did not have mathematics knowledge or interest on mathematical physics parts. He requested the provision of experimental instruments and laboratory to UCL, and the UCL committee accommodated his request and approved 200 pounds for the first budget. The expenditure gradually increased and the room for instruments and experimental demonstration was opened on Percy Street in the late 1827.[31] The

[27] Conolly et al., Statements Respecting the University of London, pp. 25–30.

[28] Bellot, *University College, London*, pp. 47–59.; A. Craik, *Mr Hopkins' Men: Cambridge Reform and British Mathematics in the $19^{th}$ Century* (London: Spring-Verlag, 2007), pp. 27–33.; Christopher Phillips, "Augustus De Morgan and the Propagation of Moral Mathematics", *Studies in History and Philosophy of Science* 36 (2005), pp. 105–133.;

[29] S. De Morgan, *Memoir*, p. 30, 34.

[30] For the popular experimental lectures, Larry Stewart, *The Rise of Public Science: Rhetoric, Technology, and Natural Philosophy in Newtonian Britain, 1660–1750* (Cambridge: Cambridge University Press, 1992); Stewart, "Other Centers of Caclulation, or where the Royal Society didn't Count, Commerce, Coffee-houses and Natural Philosophy in Early Modern London", British Journal for the History of Science 32 (1999), pp. 133–53.; Laurence Brockliss, "Science, the Universities, and other Public Spaces: Teaching Science in Europe and the Americas", R. Porter ed., *The Cambridge History of Science*, pp. 65–66.; Mary Fissell and Roger Cooter, "Exploring Natural Knowledge: Science and the Popular", Porter ed., The Cambridge History of Science, pp. 134-139.; Turner, "Eighteenth-Century Scientific Instruments and Their Makers", Porter ed., *The Cambridge History of Science*, pp. 521–525.; For the critical attitudes on the mathematical science, Richard R. Yeo, *Defining Science: William Whewell, Natural Knowledge and Public Debate in Early Victorian Britain* (Cambridge University Press, 2003), pp. 75–78.; S. De Morgan, *Memoir*, p. 41.

[31] J. W. Fox, "From Lardner to Massey: A History of Physics, Space Science and Astronomy at University College, London, 1826–1975" http://www.phys.ucl.ac.uk/department/history/BFox1.html

budget for natural philosophy lectures was a significant part of total expenditure in UCL.[32]

With the opening of UCL classes, Lardner began to give experimental and popular lectures. As a reminder, UCL seemed to plan to appoint a popular experimental lecturer, remembering the letter from Brougham to Lardner on 24, May 1827. But UCL did not employ any experimental lecturer and instead Lardner undertook the job directly. In the *Second Statement*, Lardner explained that he would "deliver short courses of lectures, in a popular style, on particular subjects, more particularly on those departments of the science which have derived interest from recent discovery and improvement or from their useful application in the arts, manufactures, and commerce."[33] The popular and experimental nature of his lecture increased over time. In the *London University Calendar* of 1831, He explained his popular lectures would be "adapted for medical students, and various persons already engaged in professions or businesses, and in general to all who do not desire to pursue the science into minute detail, or mathematical investigation," and "be copiously illustrated by experimental apparatus, models, drawings, &c."[34] And then he just introduced only popular lectures on astronomy, mechanics, hydrostatics, pneumatics, optics, and heat in detail.[35]

While Lardner's popular lectures were well-received, UCL students began to lose interest in the regular lectures about mathematical natural philosophy by Lardner. Many students already had gotten some knowledge about natural philosophy through popular experimental lectures by Lardner before they could attend his regular mathematical lectures. In this situation, they did not have a necessity taking difficult lectures. After all, the number of students who attended Lardner's regular natural philosophy classes in 1830 was only 8.[36]

As the circumstances of Lardner's regular mathematical lectures began to worsen, explaining and persuading the usefulness or value of studying mathematics became more complex and urgent problem in UCL. How De Morgan worried about it can be shown in the lecture delivered at the opening of the classes of mathematics, natural philosophy, and chemistry in late 1830. At first, De Morgan pointed out that the foundation of science is mathematics, and mathematics has the similar experimental features with other science parts. For example, he explained the efficiency of geometry can be promoted when students make a reasonable inference based on the facts by observation.[37] He deplored the UCL situation that "the costliness and unusual nature of the apparatus employed, the time and skill required for many of the processes, and above all, the interesting and popular nature of the results lead many who are unacquainted with the real state of the case to suppose that these branches of knowledge are wholly dependent upon experiment and not at all upon reasoning and demonstration." And then, he stressed that mathematical thinking or theoretical reasoning is necessary for the study of physical sciences as well.[38] He persuaded that the difficulties of mathematics are much exaggerated.[39] He thought mathematics as the foundation of accurate knowledge, and regretted the study

[32]"Statement of Receipt and Expenditure from $1^{st}$ January to $31^{st}$ December, 1827", *Hume Tract 215*, UCL Special Collection, p. 11.

[33]London University, *Second Statement*, p. 51.

[34]London University, *London University Calendar of 1831*, pp. 59–60.

[35]London University, *London University Calendar of 1831*, pp. 60–64.

[36]Fox, "From Lardner to Massey"

[37]De Morgan, *Remarks on Elementary Education in Science, An Introductory Lecture, Delivered at the Opening of the Classes of Mathematics, Physics, and Chemistry in the University of London, November 2, 1830* (London: John Taylor, 1830), p. 3.

[38]De Morgan, *Remarks on Elementary Education in Science*, P. 5.

[39]De Morgan, *Remarks on Elementary Education in Science*, P. 12.

of mathematics as to being delayed so late.[40]

In this situation, De Morgan could not justify the value of mathematics by the application of mathematical method to natural philosophy because teaching mathematics as the preparation for mathematical natural philosophy was futile in UCL. An urgent need was not to bring mixed mathematics parts from natural philosophy professor and to teach the advanced mathematics but to make young students to get the basic knowledge of mathematics, and to understand the exact meaning of mathematical terminology and the basic principles of mathematical demonstration. Since then, De Morgan's intellectual activities were concentrated on teaching pure mathematics, publishing texts on pure mathematics parts, contributing articles to educational journal about elementary mathematics education, and pursuing proper methods for training students to reason logically through mathematical logic.[41]

## 5 Conclusion

While De Morgan served for more than thirty years in UCL, the education of mathematics in UCL was consolidated and developed, and some students who received the teaching from De Morgan established the pure mathematics-centered academic society, London Mathematics Society in 1865. De Morgan's case shows that the curriculum can be constituted not by the intention of the professor or the institution, but by the accidental, systematic, or adjacent area related factors. And then, this study suggests that for the better understanding of the intellectual activities by the certain mathematician, it is necessary to examine the institutional and interdisciplinary contexts surrounding the mathematician besides mathematical matters.

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[40] De Morgan, *Remarks on Elementary Education in Science*, P. 11.

[41] I examined De Morgan's intellectual activities minutely in the $4^{th}$ , $5^{th}$, and $6^{th}$ chapters of my Ph.D. dissertation. Su Nam Cho, *The Understanding of Pure Mathematics Developments in England through the Mathematics Education by Augustus De Morgan: On the Boundary between Adjacent Areas* (Seoul National University, 2012)

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