

## APPENDIX I

### AN INQUIRY INTO THE WORKING METHODS OF MATHEMATICIANS

Translated from *L'Enseignement Mathématique*,  
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1. At what time, as well as you can remember, and under what circumstances did you begin to be interested in mathematical sciences? \*Have you inherited your liking for mathematical sciences? Were any of your immediate ancestors or members of your family (brothers, sisters, uncles, cousins, etc.) particularly good at mathematics? Was their influence or example to any extent responsible for your propensity for mathematics?

2. Toward what branches of mathematical science did you feel especially attracted?

3. Are you more interested in mathematical science per se or in its applications to natural phenomena?

4. Have you a distinct recollection of your manner of working while you were pursuing your studies, when the goal was rather to assimilate the results of others than to indulge in personal research? Have you any interesting information to offer on that point?

5. After having completed the regular course of mathematical studies (which, for instance, corresponds to the program of the Licence mathématique or of two Licences<sup>1</sup> or of the Aggregation,<sup>2</sup> in what direction did you consider it expedient to continue your studies? Did you endeavor, in the first place, to obtain a general and extensive knowledge of several parts of science before writing or publishing anything of consequence? Did you, on the contrary, at first try to penetrate rather deeply into a special subject, study-

\* Items preceded by an asterisk appeared in Vol. VI.

<sup>1</sup> French grade corresponding to B.A. and M.A. degrees.

<sup>2</sup> A grade, or rather a competition, required for teaching in high schools.

ing almost exclusively what was strictly requisite for that purpose, and only afterwards extending your studies little by little? If you have used other methods, can you indicate them briefly? Which one do you prefer?

6. Among the truths which you have discovered, have you attempted to determine the genesis of those you consider the most valuable?

7. What, in your estimation, is the role played by chance or inspiration in mathematical discoveries? Is this role always as great as it appears to be?

8. Have you noticed that, occasionally, discoveries or solutions on a subject entirely foreign to the one you are dealing with occur to you and that these relate to previous unsuccessful research efforts of yours?

\*8b. Have you ever worked in your sleep or have you found in dreams the answers to problems? Or, when you waken in the morning, do solutions which you had vainly sought the night before, or even days before, or quite unexpected discoveries, present themselves ready-made to your mind?

9. Would you say that your principal discoveries have been the result of deliberate endeavor in a definite direction, or have they arisen, so to speak, spontaneously in your mind?

10. When you have arrived at a conclusion about something you are investigating with a view to the publication of your findings, do you immediately write down the part of your work to which that discovery applies; or do you let your conclusions accumulate in the form of notes and begin the redaction of the work only when its contents are important enough?

11. Generally speaking, how much importance do you attach to reading for mathematical research? What advice in this respect would you give to a young mathematician who has had the usual classical education?

12. Before beginning a piece of research work, do you first attempt to assimilate what has already been written on that subject?

13. Or do you prefer to leave your mind free to work unbiased and do you only afterwards verify by reading about the subject

so as to ascertain just what is your personal contribution to the conclusions reached?

14. When you take up a question, do you try to make as general a study as possible of the more or less specific problems which occur to you? Do you usually prefer, first to study special cases or a more inclusive one, and then to generalize progressively?

15. As far as method is concerned, do you make any distinction between invention and redacting?

16. Does it seem to you that your habits of work are appreciably the same as they were before you had completed your studies?

17. In your principal research studies, have you followed the same line of thought steadily and uninterruptedly to the end, or have you laid it aside at times and subsequently taken it up again?

18. What is, in your opinion, the minimum number of hours during the day, the week, or the year, which a mathematician who has other demands on his time should devote to mathematics so as to study profitably certain branches of these same mathematics? Do you believe that one should, if one can, study a little every day, say for one hour at the very least?

19. Do artistic and literary occupations, especially those of music and poetry, seem to you likely to hamper mathematical invention, or do you think they help it by giving the mind temporary rest?

19a. What are your favorite hobbies, pursuits, or chief interests, aside from mathematics, or in your leisure time—b. Do metaphysical, ethical, or religious questions attract or repel you?

20. If you are absorbed by professional duties, how do you fit these in with your personal studies?

21. What counsels, in brief, would you offer to a young man studying mathematics? \*b. to a young mathematician who has finished the usual course of study and desires to follow a scientific career?

#### QUESTIONS ABOUT DAILY HABITS

22. Do you believe that it is beneficial to a mathematician to observe a few special rules of hygiene such as diet, regular meals, time for rest, etc.?

23. What do you consider the normal amount of sleep necessary?

24. Would you say that a mathematician's work should be interrupted by other occupations or by physical exercises which are suited to the individual's age and strength?

25. Or, on the contrary, do you think one should devote the whole day to one's work and not allow anything to interfere with it; and, when it is finished, take several days of complete rest?

\*b. Do you experience definite periods of inspiration and enthusiasm succeeded by periods of depression and incapacity for work?

c. Have you noticed whether these intervals alternate regularly and, if so, how many days, approximately, does the period of activity last and also the period of inertia? d. Do physical or meteorological conditions (i.e., temperature, light, darkness, the season of the year, etc.) exert an appreciable influence on your ability to work?

26. What physical exercises do you do, or have you done as relaxation from mental work? Which do you prefer?

27. Would you rather work in the morning or in the evening?

28. If you take a vacation, do you spend it in studying mathematics (if so, to what extent?) or do you devote the entire time to rest and relaxation?

*Final remarks.* \*Of course, there may be many other details which it would be useful to learn by an inquiry: 29a. Does one work better standing, seated or lying down; b. at the blackboard or on paper; c. to what extent is one disturbed by outside noises; d. can one pursue a problem while walking or in a train; e. how do stimulants or sedatives (tobacco, coffee, alcohol, etc.) affect the quality and quantity of one's work?

\*30. It would be very helpful for the purpose of psychological investigation to know what internal or mental images, what kind of "internal word" mathematicians make use of; whether they are motor, auditory, visual, or mixed, depending on the subject which they are studying.

If any persons who have been well acquainted with defunct mathematicians are able to furnish answers to any of the preceding questions, we ask them instantly to be kind enough to do so.

In this way they will make an important contribution to the history and development of mathematical science.

*Added by the writer.* The final question 30 corresponds to our discussion of Section VI, and it would be especially important to get further answers on it. Such answers ought to be of two different kinds, corresponding respectively to ordinary thought and to research effort.

Moreover, question 30 should be usefully supplemented by

31a. Especially in research thought, do the mental pictures or internal words present themselves in the full consciousness or in the fringe-consciousness (such as defined in Wallas's *Art of Thought*, pp. 51, 95 or under the name "antechamber of consciousness" in Galton's *Inquiries into Human Faculty*, p. 203 of the edition of 1883; p. 146 of the edition of 1910)?

31b. The same question is asked concerning the arguments which these mental pictures or words may symbolize.<sup>3</sup>

<sup>3</sup> Only a few mathematicians, until now, have answered questions 31a, and 31b, especially as concerns topological arguments such as the proof of Jordan's theorem (see Section VII, p. 103). For all of them without any exception, it is the geometrical aspect of the argument which directly appears in the full consciousness. One or two of them immediately feel the possibility of arithmetizing any link of it and are even able to find that arithmetization (so that it must be present in their fringe-consciousness); for others, it would require more or less effort.