Using Java Geometry Expert as guide in the preparations for math contests

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Abstract

We give an insight into Java Geometry Expert (JGEX) in use in a school context, focusing on the Austrian school system.

JGEX can offer great support in some classroom situations, especially for solving mathematical competition tasks.

Also, we discuss some limitations of the program.

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$\rightarrow$ analytically consistent thinking, acquisition of maths skills, hypothetical-deductive thinking, inductive reasoning.

Olympic training courses in Austrian regions

Year 2022/23 (see `https://oemo.at/OeMO/Kurs/2023`)

Region	*Population (Jan. 2022)*	*Number of courses*
Burgenland	297583	0
Carinthia	564513	5
Lower Austria	1698796	7
Upper Austria	1505140	**18**
Salzburg	560710	2
Styria	1252922	**33**
Tyrol	764102	6
Vienna	1931593	14
Vorarlberg	401647	3
Overall	8977006	88

Preparation day for young learners

2 February 2023, Upper Austria, Linz, Johannes Kepler University

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Geometry problems to apply the inscribed angle theorem

A collection by Ralf Roupec, olympic trainer, region Freistadt, 2018

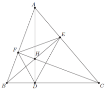
Aufgaben zum Randwinkelsatz

Ein nützlicher Satz zu Beginn

1) Folgende Aussagen sind äquivalent:
   - i) $ABCD$ ist ein Sehnenviereck.
   - ii) Die Punkte A, B, C und D liegen auf einem Kreis.
   - iii) $\measuredangle ABC + \measuredangle CDA = 180°$
   - iv) $\measuredangle ABD = \measuredangle ACD$

Aufgaben und Fragestellungen zum Schärfen des geometrischen Blicks

2) Gegeben sei ein spitzwinkeliges Dreieck ABC. Weiters seien D, E und F die Fußpunkte der Höhen h_a, h_b und h_c.



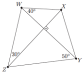
Fragestellungen zu dieser Figur

   a) In der oben dargestellten Figur gibt es sechs Sehnenvierecke. Gib sie an!

   b) Zeige, dass H der Inkreismittelpunkt des Dreiecks DEF ist.

3) Die Diagonalen des Vierecks $WXYZ$ stehen zueinander normal. Weiters sei $\measuredangle WZX = 30°$, $\measuredangle XWY = 40°$ und $\measuredangle WYZ = 50°$.

   Berechne die Winkel $\measuredangle WZY$ und $\measuredangle WXY$!



4) $ABCDE$ sei ein konvexes Fünfeck, mit der Eigenschaft, dass $BCDE$ ein Quadrat ist und dass $\measuredangle BAE = 90°$. Der Diagonalenschnittpunkt des Quadrats werde mit O bezeichnet.
   Zeige, dass AO den Winkel $\measuredangle BAE$ halbiert!

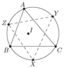
5) Es sei ABC ein spitzwinkeliges Dreieck und E und F die Fußpunkte der Höhen h_b und h_c. M sei der Mittelpunkt der Seite BC.

   a) Zeige, dass ME und MF Tangenten an den Umkreis von AFE sind.

   b) Zeige, dass die zu BC parallele Gerade durch den Punkt A ebenfalls eine Tangente des Umkreis von AFE ist.

6) Es sei ABC ein spitzwinkeliges Dreieck mit dem Umkreis k. Es sei X der Mittelpunkt des Bogens BC, der A nicht enthält. Die Punkte Y und Z sind analog definiert (vgl. Skizze)

   Zeige, dass der Höhenschnittpunkt von XYZ der Inkreismittelpunkt von ABC ist.



7) ***(BAMO 1999/2)*** Es sei $O = (0/0)$, $A = (0/a)$ und $B = (0/b)$, wobei $0 < a < b$. k sei der Kreis mit dem Durchmesser AB und P ein beliebiger Punkt von k. Die Gerade PA schneide die x-Achse im Punkt Q.
   Zeige, dass $\measuredangle BQP = \measuredangle BOP$.

Schwierigere Aufgaben

8) Gegeben sei ein spitzwinkliges Dreieck ABC mit $BC > CA$. Die Streckensymmetrale der Strecke AB schneide die Gerade BC in P und die Gerade CA in Q. Der Fußpunkt des von P auf die Gerade CA gefällten Lotes wird mit R, der Fußpunkt des von Q auf die Gerade BC gefällten Lotes wird mit S bezeichnet.
   Zeige, dass die Punkte R, S und der Mittelpunkt M der Strecke AB auf einer Geraden liegen.

9) Umkreises von AFE ist. Sei ABC ein spitzwinkeliges Dreieck mit dem Umkreis U und sei der Punkt T so gewählt, dass TA eine Tangente an den Umkreis ist und $\angle TCB = 90°$. Sei weiters D ein Punkt auf der Seite BC mit der Eigenschaft, dass $TD \parallel AB$.
   Zeige, dass die Gerade DU durch den Punkt A verläuft.

10) ***(IMO Shortlist 2010)*** Sei ABC ein spitzwinkeliges Dreieck mit den Höhenfußpunkten D, E, F auf den Seiten BC, CA und AB. Einer der Schnittpunkte des Umkreises von ABC mit der Gerade EF sei P. Die Geraden BP und DF schneiden sich im Punkt Q.
   Zeige: $AP = AQ$

11) ***(Russland 1996)*** $ABCD$ ist ein Sehnenviereck. Die Punkte E und F liegen auf der Seite BC wobei E näher bei B liegt als F. Weiters ist bekannt, dass $\measuredangle BAE = \measuredangle CDF$ und $\measuredangle EAF = \measuredangle FDE$.
   Zeige, dass $\measuredangle FAC = \measuredangle EDB$.

7) **BAMO (Bay Area Mathematical Olympiad) 1999/2:**

Set $O = (0, 0)$, $A = (0, a)$, $B = (0, b)$, where $0 < a < b$. Let k be the circle with diameter AB, and let P be an arbitrary point on k. The line PA intersects the x-axis at point Q.

Show that $\angle BQP = \angle BOP$.

Java Geometry Expert
Java Geometry Expert 0.80
Last modified on 2023-04-29
Java version 11.0.20.1
Java Geometry Expert is free under GNU General Public License (GPL).
The user may download and distribute it freely.
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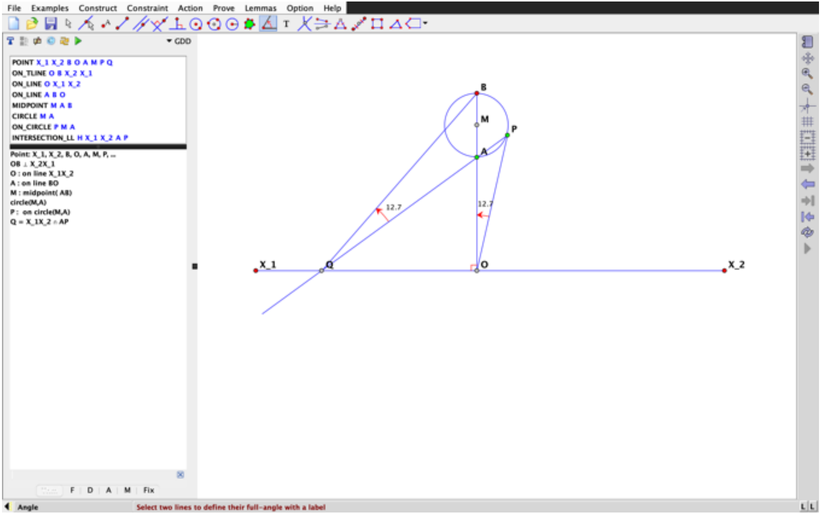
for more information,please visit: https://github.com/kovzol/Java-Geometry-Expert

A solution of BAMO 1999/2 with JGEX



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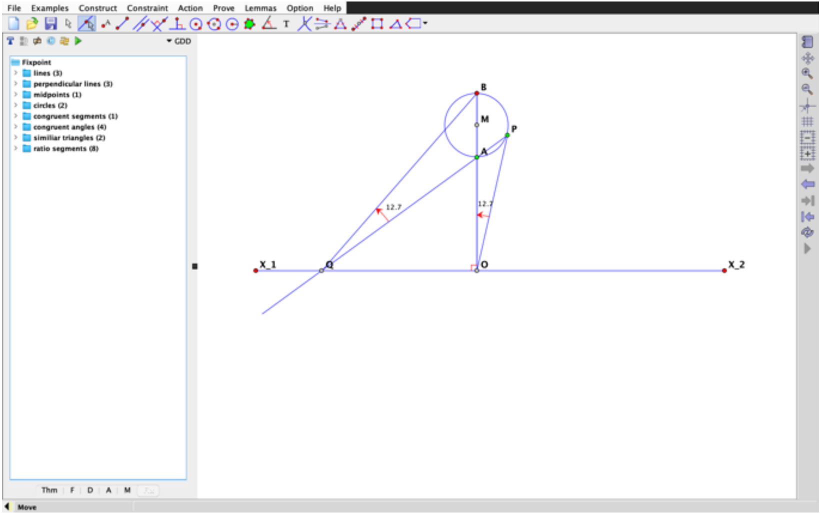

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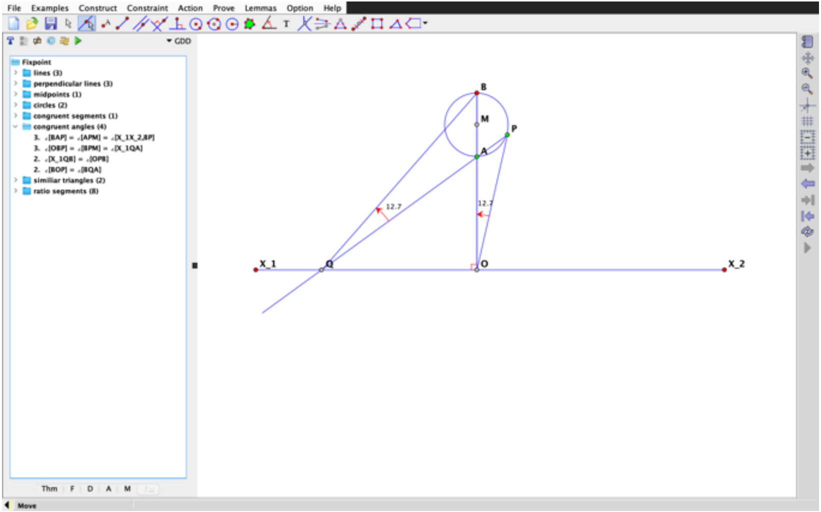

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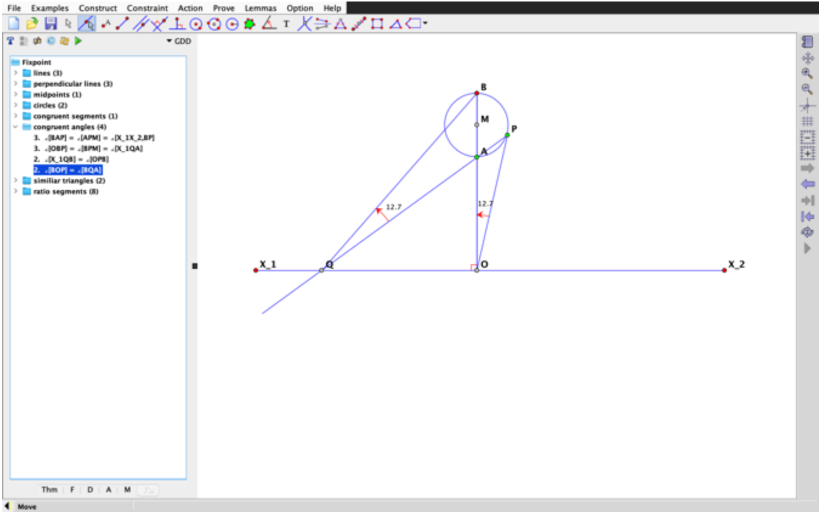

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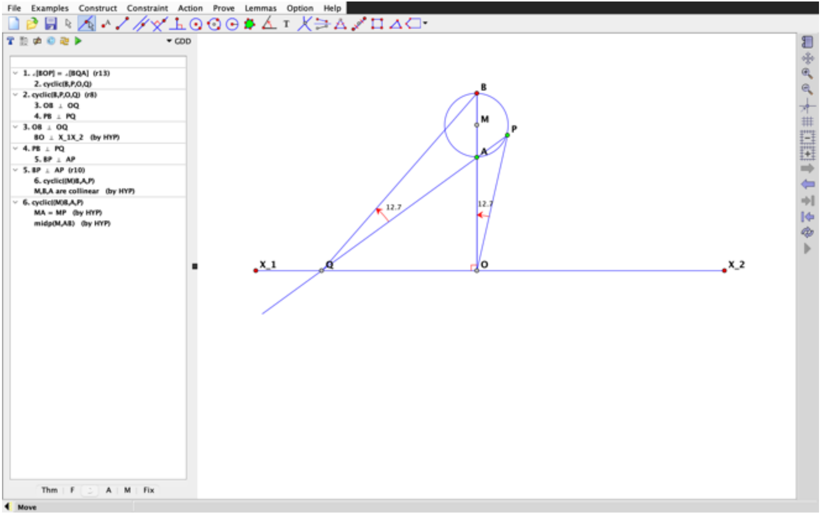
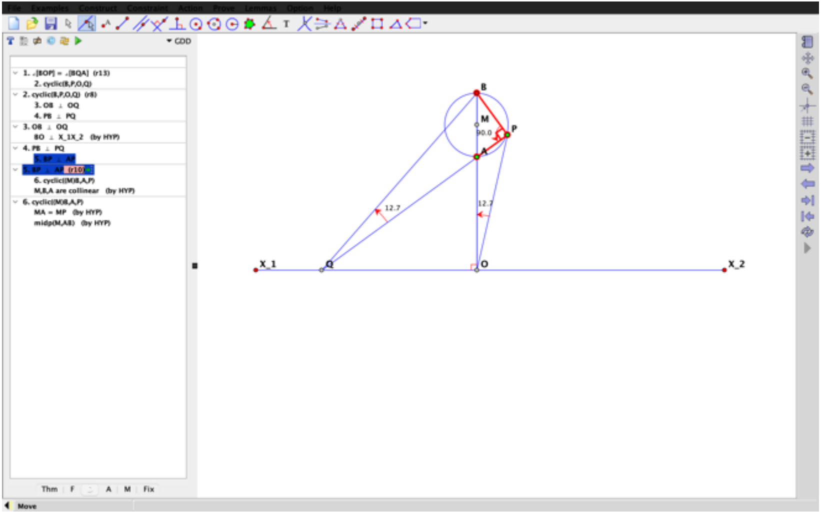


Steps of the proof



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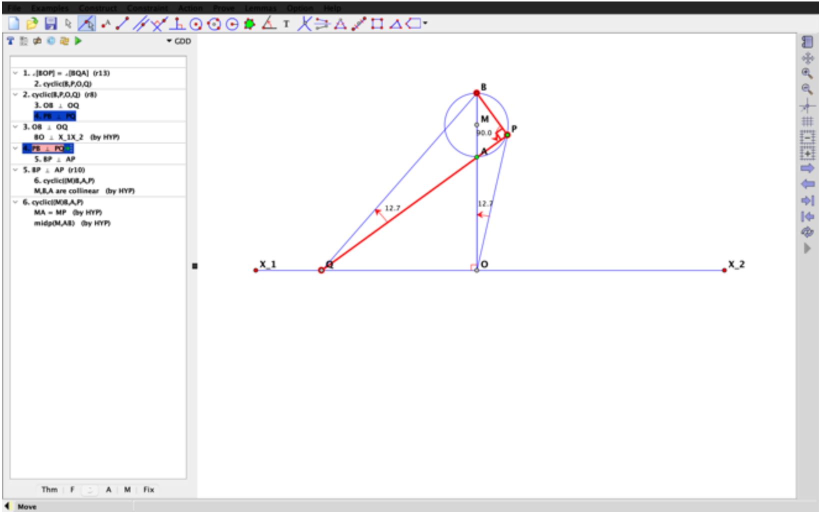

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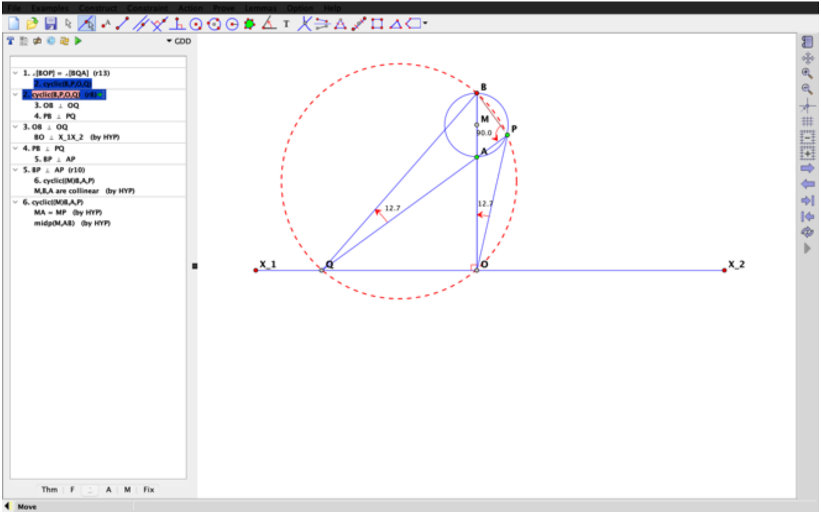
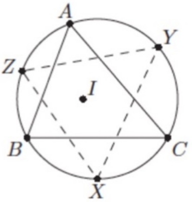
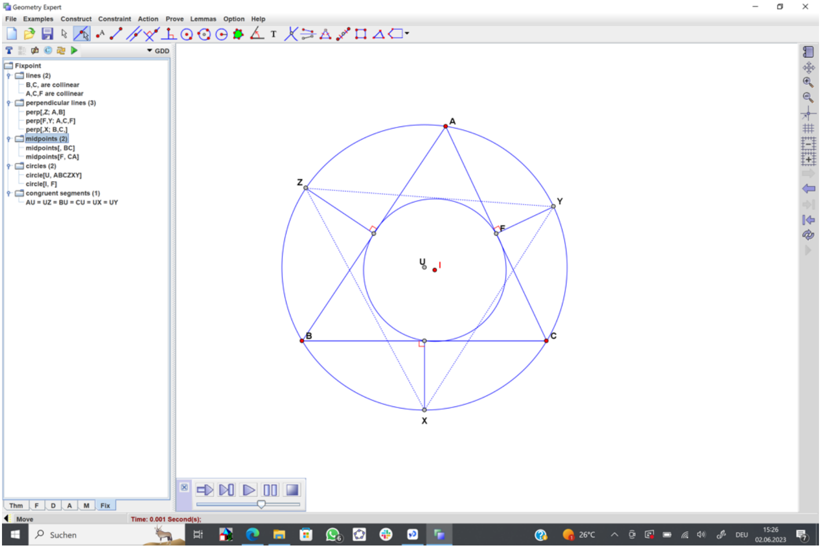


6) Let ABC be an acute triangle with circumcircle k. Let X be the midpoint of the arc BC such that A is not included in it. The points Y and Z are defined analogously.

Show that the orthocenter of XYZ is the center of the incircle of ABC.



An attempt to solve Problem 6 with JGEX



Conclusion on JGEX

+ Sophisticated user interface
− Too complex for beginners
− Only English, Chinese, German, Portuguese, Persian and Serbian are supported (some of them just partially)
+ Visual proofs are very useful even for university students
− Formulating the problem can be challenging

Future work (master thesis for I. G.)

- More problems to checks
- Find suggestions to improve the user interface (possibly joint work with Alexander Vujic)
- Measure impact of JGEX on structured thinking at secondary level
- Advertise JGEX among teachers (with workshops and tutorials)

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